Public Willingness to Pay for Improvements in Ecosystem Services and Landowner Willingness to Accept for Wetlands Conservation: An Assessment of Benefit Transfer Validity and Reliability Using Choice Experiments in Several Canadian Watersheds

by

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Abstract

Benefit-cost analyses are often used to evaluate the economic efficiency of proposed policies or projects. Such analyses require analysts to estimate the benefits and costs in monetary terms of any changes related to the policy being analyzed, including to the environment (e.g., changes in water or air quality). However, estimating these monetary values can be difficult since prices are often not available due to market failure. As such, several non-market valuation techniques have been developed for use in assessing these monetary values, including original research techniques, such as choice experiments, and benefit transfer which applies existing non-market values estimated using original research techniques to other contexts (e.g., locations). Several studies have evaluated the validity and reliability of benefit transfer in a variety of contexts. In this thesis, I contribute to this literature by assessing transfers in contexts not yet evaluated. In doing so, I use choice experiments to investigate landowner preferences for wetlands conservation in two Ontario watersheds and elicit the general public's willingness to pay values for changes in ecosystem services in four Canadian watersheds. This research resulted in four papers. The first paper, motivated by the loss of wetlands in Southern Ontario, involves assessing the preferences and willingness to accept (WTA) of farm and non-farm landowners for enrolling their land in wetlands conservation programs. Though preferences and values are heterogeneous, many landowners are willing to enrol and at moderate cost. Using data from this paper, in the second and third papers I evaluate the validity and reliability of transfers of WTA and predicted program participation market shares, respectively. Results suggest that transfers of WTA are similarly valid and reliable to transfers of willingness to pay, while transfers of predicted participation market shares are considerably more valid and reliable than a parallel assessment of transfers of WTA. Finally, using data from the general public survey I evaluate alternatives for reconciling quantitative choice experiment attributes with differing levels for benefit transfer. A key finding of this research is that transfers rooted in "relative" preferences are more valid and reliable than transfers rooted in "absolute" preferences.

Keywords: benefit transfer; choice experiment; willingness to pay; willingness to accept; wetlands; convergent validity

Dedication

For family, friends, and colleagues — especially my two boys.

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My PhD has been an enjoyable, though non-linear, journey and I have many people to thank. I began in early 2009 as a student in the Faculty of Forestry at the University of British Columbia in Dr. Thomas Maness's lab with the intention of working on forest product supply chains and ecosystem services. However, Dr. Maness left for Oregon State University within the year and I eventually moved to Simon Fraser University. Sadly, Dr. Maness recently passed away. I benefited from my time at UBC through research and coursework as well as the personal relationships with Dr. Maness and members of his lab, in particular Francisco Vergara and his family. I transferred to the School of Resource and Environmental Management (REM) at SFU in 2010 under the supervision of Dr. Wolfgang Haider, a connection made possible by Dr. Van Lantz who also joined my committee (Dr, Lantz supervised my master's degree at the University of New Brunswick). The committee was completed with the addition of Dr. Duncan Knowler. At SFU I benefited from the coursework and relationships with faculty and students alike. However, on August 17, 2015 I learned that Wolfgang had been in an accident in Austria and he passed away on August 24th. This was devastating for his family and friends, indeed everyone at REM myself included. In my experience, REM's response was thoughtful and they have accommodated the members of Wolfgang's lab. Dr. Duncan Knowler subsequently took over as senior supervisor and Dr. Pascal Haegeli was added to my supervisory committee.

From my time at SFU I have many people to thank, including: 1) all members of my supervisory committee; 2) the other students working on the same research project (David Angus, Toni Anderson, and Monica McKendy); 3) the other students and researchers at REM, including the too many to name members of Wolfgang's lab (those I worked most closely with include Ben Beardmore, Steve Conrad, Nina Mostegl, Amy Suess (now Kitchen), Sergio Fernandez Lozada, Kornelia Dabrowska, and Rodrigo Solis Sosa) as well as the many other students whose office space was in the Tourism Lab; 4) the members of REM's Water Research Group (Steve Conrad, Cedar Morten, Sarah Breen, Lee Johnson, Dr. Murray Rutherford, and David Angus); and 5) last, but certainly not least, the REM staff. Several others helped out during the research process and I'd like to acknowledge the help of Tatiana Koveshnikova (Credit River Conservation Authority), Jeff Brick (Upper Thames Conservation Authority), and Tracy Ryan (Grand

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Chapter 1.

Introduction

Natural capital provides many goods and services that benefit society, ranging from forest and agricultural products to wildlife habitat, water purification, and carbon sequestration (Costanza et al. 1997; Millennium Ecosystem Assessment 2005). Ecosystem services are "the benefits that people obtain from ecosystems" (Vihervaara et al. 2010) or, more specifically, "the aspects of ecosystems utilized (actively or passively) to produce human well-being" (Fisher et al. 2008).[1] Globally, environmental degradation is a significant threat to the flow of many ecosystem services and therefore the well-being of current and future generations (Millennium Ecosystem Assessment 2005; Liu et al. 2010; Vihervaara et al. 2010). This degradation stems at least in part from market failures which occur when markets fail to incorporate all benefits provided by or costs imposed on ecosystems (Brown et al. 2007; Bateman et al. 2011).[2] Ultimately, market failures lead to environmental management practices that undersupply ecosystem services (Fisher et al. 2008).

In response to this problem, governments around the world have used various policy tools, such as prescriptive regulation or market-based instruments (Fisher et al. 2008; Kemkes et al. 2010). In Canada, governments have relied on command-and-control regulation (e.g. minimum standards), research and infrastructure spending (e.g. water treatment), as well as pressure from the general public and industry peers to solve market failures (National Round Table on the Environment and the Economy 2002). Canadian governments have also used programs incorporating economic incentives (Kenny et al. 2011). A well-known example in Canada is the pricing of carbon emissions via taxes or cap and trade systems. However, other programs may compensate landowners in some form for altering their land management to improve the supply of ecosystem services [so called payments for ecosystem services (PES) programs].

Among other criteria, it is important that such environmental policies, and their implementation, account for the benefits received by, or costs imposed on, the relevant

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[1] The Millennium Ecosystem Assessment (2003) classifies ecosystem services into four groups: 1) *supporting services* that underpin all other ecosystem services (e.g., primary production or soil formation); 2) *provisioning services*, which are the products of ecosystems (e.g., food or fuelwood); 3) *regulating services*, which result from the regulation of ecosystem processes (e.g., climate regulation or water purification); and 4) *cultural services*, which are the nonmaterial benefits of ecosystems (e.g., aesthetics or recreation).

[2] Market failures include: externalities, which occur when a third party agent is affected by the economic transactions of other agents; and public goods, which are those goods that are non-excludable and non-rivalrous in consumption (Freeman et al. 2014).

stakeholders (e.g., the general public, who consume ecosystem services, and private landowners, who supply the natural capital from which these services flow). Information on these benefits and costs can be used in a benefit-cost analysis to evaluate the economic efficiency of the alternative environmental policies being considered and to better clarify trade-offs (Wainger and Mazzotta 2011). The results of this analysis can then be used to inform government policy decisions (Freeman et al. 2014). Determining monetary values for the appropriate benefits and costs is complicated since many ecosystem services do not have market prices. As such economists have developed various valuation techniques to elicit monetary values for non-market ecosystem services in terms of willingness to pay (WTP) or willingness to accept (WTA) (Liu et al. 2010).

The papers forming my dissertation relate to non-market valuation techniques for assessing the benefits and costs of policies aimed at conserving and protecting the environment. These papers are divided into two main themes. The first theme relates to informing the discussion surrounding the design of programs targeted at conserving or restoring natural capital on private land. The second theme relates to assessing the convergent validity of benefit transfer, which is a secondary non-market valuation technique.[3] The goal of this introductory chapter is threefold: 1) it serves as an introduction to the topics covered in the subsequent chapters; 2) it provides the reader with certain basic information related to these topics, though not necessarily included in these chapters; and 3) it provides a summary of my dissertation's findings.

1.1. Theme 1: Private Landowner Preferences for Conservation Practices

The supply of ecosystem services from natural capital situated on private land is often threatened due to market failures (Jack et al. 2008). A common solution to this problem is intervention by governments or non-governmental organizations. The primary goal of these interventions is to modify the behaviour of stakeholders, such as farmers or woodlot owners, leading them to adopt more environmentally benign practices. Regulation is a common government intervention which requires stakeholders to comply with legislated design or performance standards. While regulations can effectively

[3] I refer to benefit transfer as a 'secondary' valuation technique since it relies on secondary data, while I refer to valuation techniques using original research as 'primary' valuation techniques (e.g., stated or revealed preference techniques involve original research).

address many environmental problems, other instruments that harness economic incentives are increasingly commonplace in conservation policy as they are often more efficient (Fisher et al. 2008). Such economic instruments include payments to private landowners for voluntarily protecting land or changing their management practices to increase the supply of ecosystem services (Brown et al. 2007). In a sense these payments modify a good or service's price to reflect its true benefit or cost, thus acting as an incentive for landowners to change their behaviour.

Examples of such programs include the Conservation Reserve Program in the United States (United States Department of Agriculture 2017) and agri-environmental measures that are part of the Common Agricultural Policy in Europe (European Commission 2005). In Canada the Growing Forward 2 policy framework jointly administered by the federal government and its provincial and territorial counterparts includes a component that covers a portion of the costs of implementing certain beneficial management practices (Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture, Food, and Rural Affairs 2016). Non-governmental organizations also use financial instruments to achieve environmental goals. The Alternative Land Use Services (ALUS) program, which pays farmers to restore ecosystems on their land to provide ecosystem services, is also gaining momentum in Canada and is currently active in regions of Alberta, Saskatchewan, Ontario, and all of Prince Edward Island (ALUS Canada 2018). There are also local initiatives such as the Langley Ecological Services Initiative pilot project in Metro Vancouver, British Columbia, a farmer-led program in the early stages of development that is similar to ALUS (Langley Sustainable Agriculture Foundation 2017). Another example is Ducks Unlimited Canada which purchases conservation easements on ecologically significant land and even piloted an auction for such purposes in 2002 (Brown et al. 2011).

From an economic perspective, the decision of a landowner to enrol some of their land into a conservation program that provides an incentive payment depends on how this change affects their utility (or well-being). When deciding whether to voluntarily enrol some of their land in a payments-based conservation program, a landowner compares the utility they may derive from participating in the program to the utility obtained from not participating in the program. They will adopt more environmentally beneficial land management practices as part of an incentive payment program if the utility they expect to gain from doing so is at least as large as the utility they derive from the status quo (Cooper and Keim 1996). In a sense if the incentive payment is larger than the opportunity cost of implementing a conservation action then landowners will enrol some of their land.

For policy-makers or managers, the problem is to determine how to design and implement conservation programs to best encourage landowner participation at least cost (Vercammen 2011). If such a program includes an incentive, then the appropriate financial incentive to offer to landowners must be determined. The incentive should be sufficiently large to induce landowners to participate and enrol enough of their land so as to achieve the program's environmental objectives. However, payments to landowners and other program costs are constrained by budgets (Naidoo et al. 2006). While the payment, which reflects landowner WTA, should be larger than the opportunity cost of adopting the conservation action, this cost is only known by the targeted landowner (Chen et al. 2010). Opportunity costs, and thus the payment required to induce participation, also often vary across landowners reflecting heterogeneous preferences or land characteristics (Fraser 2009). An additional problem is determining how characteristics of the program other than the financial incentive may affect a landowner's WTA and decision to participate. As with opportunity costs, landowner preferences for non-financial program characteristics may be heterogeneous (Broch and Vedel 2012). Several studies assess these issues for landowners using a variety of techniques (e.g., Cooper and Keim 1996; Cortus et al. 2011; Franzén et al. 2016; Hansen et al. 2018). However, the findings of such studies may not necessarily be applicable in all situations necessitating further study in other contexts. As such, Chapter 2 reports on a case study I conducted regarding landowner preferences for incentive-based conservation programs in Southwestern Ontario. The results of this study are inputs into Chapters 3 and 4.

1.2. Theme 2: Benefits Transfer

It is common for governments to require a benefit-cost analysis of policies and regulations (Treasury Board of Canada Secretariat 2007; United States Environmental Protection Agency 2014). In fact, such economic analyses are required by law in the United States for certain regulations (Newbold et al. 2018). These benefit-cost analyses often require the valuation of non-market goods and services, especially in situations where policies or regulations may have environmental impacts (e.g., affect ecosystem services). While original research using revealed or stated preference techniques is preferred, the resources required to undertake a proper valuation study, such as time, money, or expertise, can be prohibitive (Brouwer 2000). In these cases analysts have a few options. They may skip valuation altogether, essentially leaving the non-market good or service out of the benefit-cost analysis, or use a secondary valuation technique known as benefit transfer.

Benefit transfer involves assigning new economic values at the site or population of interest, known as the policy site, using existing information that was collected for other similar sites or populations, known as study sites, employing original valuation exercises (Johnston et al. 2015). Two main approaches to benefit transfer have been developed: 1) unit value transfer; and 2) function transfer. *Unit value transfer* involves transferring estimates of willingness to pay (or accept) from the study site(s) to the policy site. The transferred value may be a single estimate, a range of estimates, or the central tendency of a set of estimates. These estimates can either be transferred directly, which is known as simple unit transfer, or they can be adjusted for differing characteristics according to expert opinion which is known as unit transfer with income (or other) adjustments. Following Johnston et al. (2015), the existing marginal willingness to pay (accept) value for study site j and population s reported in the primary valuation literature can be denoted $\bar{y}_{js}$, while the value being estimated at policy site $i \neq j$ and population $r \neq s$ is denoted as $\hat{y}_{ir}^{BT}$. Simple unit value transfer for a change in a similar good or service is thus represented as Equation 1.1 (note that the site and population need not differ simultaneously).

$$\hat{y}_{ir}^{BT} = \bar{y}_{js} \tag{1.1}$$

For adjusted value transfer Equation 1.1 is augmented by function f, which adjusts the value from the study site for any site differences for transfer to the policy site (Equation 1.2).

$$\hat{y}_{ir}^{BT} = f\left(\bar{y}_{js}\right) \tag{1.2}$$

Equations 1.1 and 1.2 can be modified to accommodate multiple primary valuation estimates (see Johnston et al. 2015). In general, *unit value transfers* assume that the marginal values of changes in the non-market goods or services at the study and policy sites are the same or at least similar, as are the sites themselves. However, marginal values often markedly differ and adjustments can only partially address these differences. If this is the case then *function transfer* may be more appropriate, especially when sites differ substantially (Johnston et al. 2015). This technique involves using more information from the study site by transferring a model estimated at this site that relates willingness to pay (or accept), $\hat{y}_{js}$, to its determinants such as study site characteristic variables ($\boldsymbol{x}_{js}$) and corresponding parameters ($\widehat{\boldsymbol{\beta}}_{js}$) via a linear or non-linear function (g) (Equation 1.3).

$$\hat{y}_{js} = g\left(\boldsymbol{x}_{js}, \widehat{\boldsymbol{\beta}}_{js}\right) \tag{1.3}$$

The key requirements for *function transfer* are a model estimated from the study site and data to populate this model's variables from the policy site. In many cases data for certain of the variables $\boldsymbol{x}_{js}$ will not be available at the policy site and the set of variables is therefore divided into those with ($\boldsymbol{x}_{ir}^{1}$) and without ($\boldsymbol{x}_{js}^{2}$) such data. Thus, willingness to pay (or accept) at the policy site can be estimated according to Equation 1.4.

$$\hat{y}_{ir}^{BT} = g\left(\left[\boldsymbol{x}_{ir}^{1}, \boldsymbol{x}_{js}^{2}\right], \widehat{\boldsymbol{\beta}}_{js}\right) \tag{1.4}$$

As illustrated above *function transfer* may involve transferring only a single model. An alternative is to augment the single model with multiple benefit functions resulting in a range of value estimates for use at the policy site. More advanced *function transfer* approaches include meta-analysis and structural benefit transfers (see Johnston et al. 2015). Briefly, the former involves using data from multiple primary valuation studies to develop a meta regression model that relates willingness to pay (or accept) to the characteristics of each study (e.g., valuation technique, year conducted, resource attributes, etc.). The latter approach, although much more complicated and involved, addresses certain limitations of the prior approaches by developing a theoretically grounded utility function using data from multiple primary valuation studies.

Using benefit transfer for valuing the environment has been somewhat controversial. Some of this controversy is rooted in general criticisms of non-market valuation and benefit-cost analysis. However, problems with the accuracy of benefit transfer have led researchers to express concerns about the technique. Three main sources of error are thought to reduce the accuracy of benefit transfer (Rosenberger and Stanley 2006): 1) measurement error; 2) publication selection bias; and 3) generalization error. Measurement error arises when the studies that are the source of the transferred values or functions contain either random errors or errors resulting from researcher assumptions and judgements. Publication selection bias stems from the fact that most original valuation research has been published for reasons other than to inform benefit transfer and the criteria for its publication differ from the criteria useful for benefit transfer. Generalization error results from the process of transferring value estimates from study sites to policy sites with differing characteristics. If these errors are sufficiently large they may affect policy or regulatory decisions informed by benefit transfer. However, while these errors certainly complicate benefit transfer they do not preclude the technique's use — in fact the use of benefit transfer is common (Boyle et al. 2010).

Also commonplace are convergent validity studies that assess the validity and reliability of the benefits transfer technique using percent errors and statistical hypothesis tests (Kaul et al. 2013; Rosenberger 2015). These studies use data from original research conducted at multiple case study sites in parallel to test the technique's validity and reliability by treating these sites as policy and study sites. Loomis (1992) conducted the initial convergent validity assessment for transfers of recreational fishing values between sites in Oregon and Washington as well as Idaho.[4] Since then these studies have become relatively common spanning several contexts with recently published examples including: Hasan-Basri and Abd Karim's (2016) examination of transfers of recreational values between two Malaysian parks; Interis and Petrolia's (2016) evaluation of transfers of WTP across locations (Louisiana and Alabama) and habitat types (oyster reefs, mangroves, and salt marshes); and Czajkowski et al.'s (2017) assessment of different functional forms for transfers across nine European countries.[5] However, certain gaps in the benefit transfer convergent validity literature remain and Chapters 3 through 5 of this dissertation report on three convergent validity studies that aim to address some of them.

[4] This paper is from a special issue of *Water Resources Research* examining the benefit transfer technique (Brookshire and Neill 1992). Similar special issues have appeared in *Ecological Economics* (Wilson and Hoehn 2006) and recently in *Environmental and Resource Economics* (Smith 2018).

[5] Kaul et al. (2013) and Rosenberger (2015) provide comprehensive lists of such convergent validity studies.

1.3. Brief Backgrounder on Non-Market Economic Valuation

1.3.1. Economic Values

Economic valuation is anthropocentric and utilitarian in that it focusses on the values of humans as defined by their preferences (National Research Council 2005). Furthermore, the values assigned to environmental features are instrumental, rather than intrinsic, meaning that economic values flow from the use of environmental goods or services rather than them having value in and of themselves (regardless of use). In sum, humans must benefit from something in order for it to have economic value. However, within this perspective there is a wide spectrum of values and one of the main frameworks is a hierarchy known as total economic value.[6] The total economic value of an environmental feature is composed of use and non-use values (Figure 1.1). Use values result from current or future human interaction with the environment, while non-use values arise from the existence of the resource without the prospect of such interaction. Use values can be subdivided into direct use values, which arise from consumptive and non-consumptive human interaction with environmental features, and indirect use values, which do not result from such direct physical use.[7] Direct use values generally result from provisioning and cultural ecosystem services (Millennium Ecosystem Assessment, 2003). Examples of these services that yield consumptive direct use values include food or timber products, while those generating non-consumptive direct use values include recreation and spiritual services. Indirect use values generally result from supporting and regulating services, examples of which include soil nutrients and pollination as well as water purification. Non-use values are composed of existence values, which arise from the existence of the environmental resource, and bequest values, which result from the environmental resource being left to

[6] The typology presented here is not the only typology of value and is also not without criticism (Admiraal et al. 2013).

[7] Hanley and Barbier (2009) distinguish between direct and indirect environmental values in a different sense. Direct values result from an environmental change that directly affects an individual’s well-being (e.g., swimmers benefit directly from an improvement in water quality). Indirect values result from a change in an ecosystem service that is an input into the production of a good or service that directly affects an individual’s well-being (e.g., improvements in water quality can also reduce the cost of producing a product such as beer, which results in price decreases that benefit consumers).

future generations (non-use values were introduced into the economics literature by Krutilla (1967)).[8]

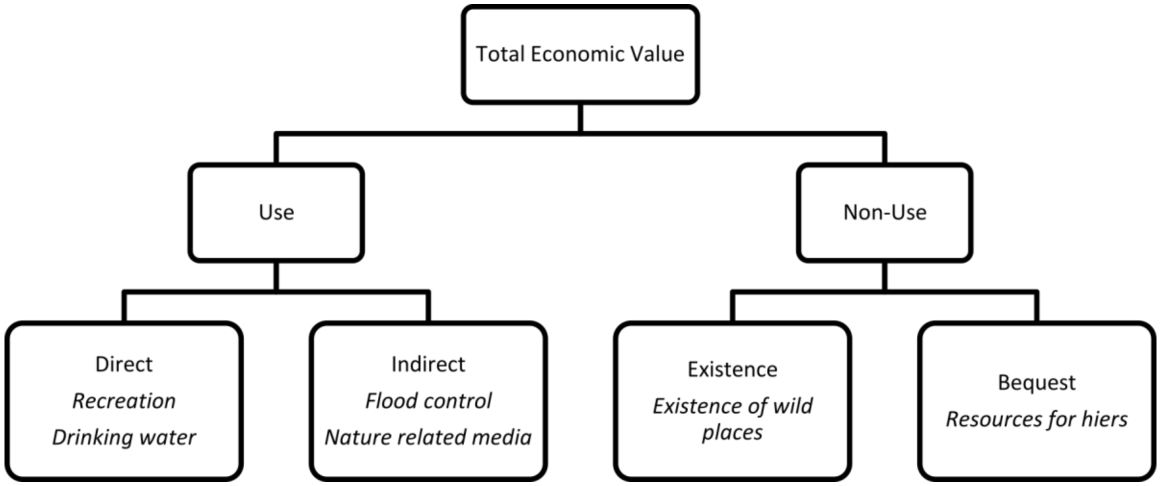

Figure 1.1: Total Economic Value
Adapted from National Research Council (2005)

1.3.2. Basics of Measures of Economic Welfare

As alluded to above, changes in economic welfare are measured using the concepts of WTP and WTA. For a change in environmental quantity or quality, WTP is the maximum amount of money an individual would trade for a positive change or to forgo a negative change, while WTA is the minimum amount of money they would require to endure a negative change or to forgo a positive change (Freeman et al. 2014). These measures of WTP and WTA are related to the more formal Hicksian terms of compensating and equivalent surplus (Table 1.1).[9]

[8] The Millennium Ecosystem Assessment (2003) notes that existence values in part reflect intrinsic values to the extent that people believe that ecosystems have intrinsic value.

[9] Similar measures for the welfare effects of changes in prices are known as compensating and equivalent variation (Freeman et al. 2014).

Table 1.1: The Relationship between Compensating and Equivalent Surplus and Willingness to Pay and Accept

Welfare Measure	Improvement	Decline
Compensating Surplus (right to status quo level of utility)	WTP to obtain a gain	WTA to accept a loss
Equivalent Surplus (right to change level of utility)	WTA to forgo a gain	WTP to avoid a loss

Adapted from Freeman et al. (2014)

These measures are grounded in the neoclassical theory of individual preferences and demand with the assumption of rational consumers (Freeman et al. 2014).[10] Individuals are assumed to best judge their own welfare and are able to order alternative goods and services according to their preferences. Researchers can draw conclusions about the welfare individuals derive from consuming alternative goods and services by observing their choices. Two key properties are important for non-market valuation: 1) non-satiation; and 2) substitutability. Non-satiation means that, all else equal, an individual will prefer more over less of a good or service. Substitutability means that if the quantity of one good or service declines, the quantity of an alternative good or service can be increased such that an individual is indifferent to the decline. Non-market valuation, which is rooted in trade-offs between money and changes in goods or services, rests on the concept of substitutability that enables the definition of trade-off ratios between different goods and services. Coupled with transitivity and quasi-concavity properties, these two properties allow the definition of a utility function that relates an individual's welfare to the bundles of goods and services they consume.

WTP and WTA flow directly from the concept of utility, which I illustrate below for a change in the quantity or quality of a continuous good or service (such as an ecosystem service). Following Freeman et al. (2014), individual utility is a function of private goods $\boldsymbol{X} = (x_1, \dots, x_j)$ and unpriced environmental goods or services $\boldsymbol{Q} = (q_1, \dots, q_j)$. The private quantity is chosen by the individual, while the quantity or quality of the environmental good or service is not since it is a public good.

$$U(\boldsymbol{X}, \boldsymbol{Q}) \tag{1.5}$$

[10] Of course there are exceptions to rationality (see Jackson (2005) for an overview).

For simplicity assume that all prices for elements of $\boldsymbol{Q}$ are zero. The prices of each element of $\boldsymbol{X}$ are $\boldsymbol{P} = p_1, \ldots, p_j$ resulting in a budget constraint of $\boldsymbol{P} \cdot \boldsymbol{X} = M$, where M represents monetary income. Given this, the individual seeks to maximize their utility subject to the budget constraint which yields conditional demand functions for the set of private goods (conditional on $\boldsymbol{Q}$).

$$x_j = x_j(\boldsymbol{P}, M, \boldsymbol{Q}) \tag{1.6}$$

Substituting the conditional demand function into the utility function yields the conditional indirect utility function.

$$V = V(\boldsymbol{P}, M, \boldsymbol{Q}) \tag{1.7}$$

For changes in the quantity or quality of a single environmental good or service from q^0 to q^1, compensating and equivalent surplus are respectively represented by Equations 1.8 and 1.9.[11] Compensating surplus is the change in income that makes an individual indifferent to a change in the quantity or quality of an environmental good or service.[12]

$$V(\boldsymbol{P}, M, q^0) = V(\boldsymbol{P}, M - CS, q^1) \tag{1.8}$$

Similarly, equivalent surplus is the change in an individual's income that yields the same level of utility as a change in the quantity or quality of an environmental good or service.

$$V(\boldsymbol{P}, M + ES, q^0) = V(\boldsymbol{P}, M, q^1) \tag{1.9}$$

The main difference between these two measures is the reference level of utility, with compensating and equivalent measures assuming a right to the status quo and change levels, respectively. This difference can be illustrated using indifference curves, which represent levels of utility (Figure 1.2). Utility is constant along a given curve and differs across curves, while different points along the curve represent alternative bundles

[11] A key assumption for both CS and ES is that the individual's utility is the same pre and post change.

[12] An alternative illustration rests on the expenditure function. For brevity, I do not do not show this here and direct the interested reader to Freeman et al. (2014).

of goods or services. The slope of the indifference curve is the trade-off ratio, or marginal rate of substitution. Given a composite private numeraire good (x) and an environmental good or service (q), the compensating surplus for an increase from q^0 to q^1 is the distance B to C (the amount of the numeraire good an individual is willing to pay for the change in q).[13] Holding q constant at its status quo, equivalent surplus is the distance A to D (the amount of the numeraire good an individual is willing to accept to forgo the change in q).

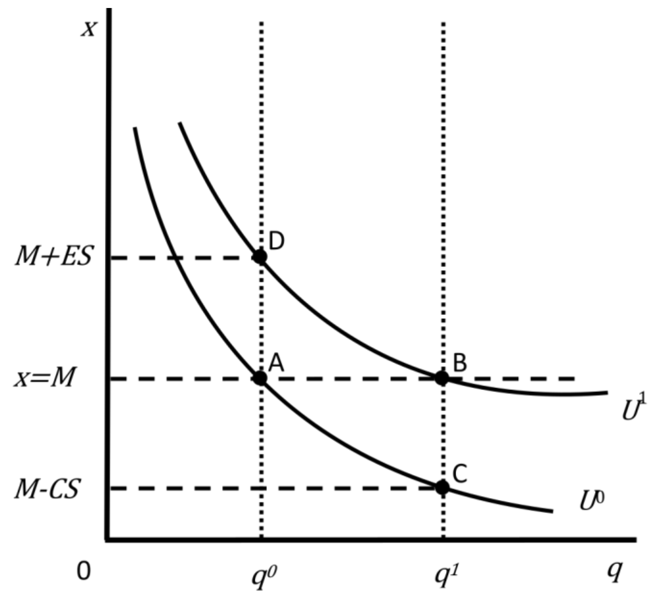

Figure 1.2: Welfare measures from indifference curves
Adapted from National Research Council (2005) and Freeman et al. (2014)

Oftentimes the changes in a good or service are discrete rather than continuous. In this case, assume that an individual selects a single good or service from $j = 1, \dots, J$ alternatives, with each alternative associated with a vector of environmental quality $\boldsymbol{Q}$ and each good j having price p_j. Given this, the deterministic conditional indirect utility function for a discrete change in the quantity or quality of an environmental good or service is represented by Equation 1.10 (this function is conditional on $\boldsymbol{Q_j}$).

$$V_j = V_j\left(M, p_j, \boldsymbol{Q_j}\right), \text{where } j = 1, \cdots, J \qquad (1.10)$$

[13] A numeraire good or service is a one whose price is set to 1 so that the price of other goods or services is reflected in terms of the numeraire. A composite good or service is one that represents a basket of goods or services.

Given the choice of two alternative goods or services j and k, the individual selects that which maximizes their utility. Compensating surplus is thus defined in Equation 1.11 for a change in each alternative's associated vector of environmental quality characteristics.

$$\mathrm{Max}_j\, V_j\left(M, p_j, Q_j^0\right) = \mathrm{Max}_j\, V_j\left(M - CS, p_j, Q_j^1\right) \tag{1.11}$$

Equivalent surplus is defined as Equation 1.12.

$$\mathrm{Max}_j\, V_j\left(M + ES, p_j, Q_j^0\right) = \mathrm{Max}_j\, V_j\left(M, p_j, Q_j^1\right) \tag{1.12}$$

While neoclassical theory posits that the compensating and equivalent surplus measures will approximate each other if the change being valued is small as are income effects, empirical evidence suggests that this will not always be the case (Kim et al. 2015). Though neoclassical theory allows for smaller differences, researchers have identified cases where the difference between the WTP and WTA measures is quite large. There are several possible explanations or theories, some consistent with neoclassical utility theory and others that are not (see Chapter 3 of this dissertation for a brief overview or Kim et al. (2015) for more details). One of the more prevalent reasons for the disparity in welfare measures, which is not consistent with neoclassical theory, is the endowment effect (Thaler 1980; Knetsch 1989; Kahneman et al. 1990).[14] In essence, an individual's status quo level of an environmental good or service, the initial endowment, will influence how they value changes from this level. This effect is rooted in the prospect theory concepts of loss aversion and reference dependence (Tversky and Kahneman 1992). Essentially losses from a reference point are valued more than gains from the same point. Following Freeman et al. (2014), Figure 1.3 illustrates the endowment effect and the asymmetric value of gains and losses. The horizontal axis represents the quality or quantity of the environmental good or service, while the vertical axis represents the compensating surplus measure as either WTP or WTA. Two value functions are plotted, w_0 and w_1, with each relating the payment or compensation required to hold utility constant when the environmental good or service changes. These functions are kinked at the reference points, where they intersect the horizontal axis,

[14] One of the researchers examining this issue, near the outset and over the following decades, was Dr. Jack Knetsch, who was a professor here at Simon Fraser University's School of Resource and Environmental Management and is currently Professor Emeritus.

with the marginal value of a gain less than the marginal value of a loss (it is easy to see that WTP to go from q_0 to q_1 (a gain) is smaller than WTA to go from q_1 to q_0 (an equivalent loss)).

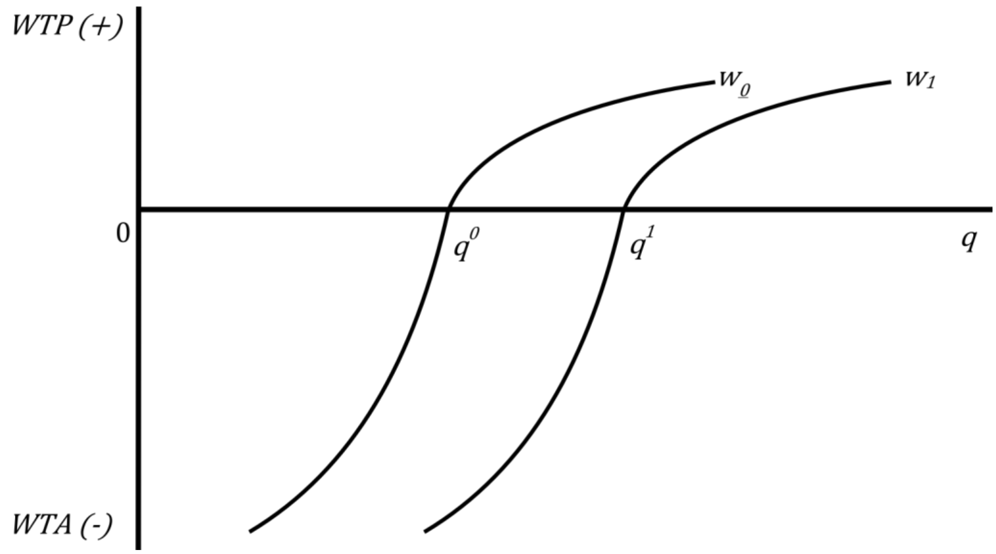

Figure 1.3: Prospect Theory Value Function
Adapted from Freeman et al. (2014)

However, there has been much debate about the endowment effect and several other experimental studies highlight situations where no such effect is observed or where the disparity is reduced (e.g., Plott and Zeiler (2007); Bateman et al. (2009); List (2011)). Furthermore, there is empirical evidence for other explanations for the disparity leading Kim et al. (2015) to summarize "…there are likely multiple factors at play in any given empirical finding of a divergence". Regardless of explanation, the disparity has implications for applied valuation and related policy since certain situations are more suited to WTA and others to WTP (as alluded to in Table 1.1).[15] Often the decision about which measure to use is related to property rights, with losses from a legally entitled position measured via WTA and gains from this position measured using WTP.

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[15] Researchers have been reluctant to use WTA, even when it is the correct measure, opting instead to use WTP. Whittington et al. (2017) outlines four main reasons: 1) responses are perceived as unreliable as WTA may lack incentive compatibility in certain cases (e.g., open-ended question formats); 2) higher rate of responses deemed non-conforming (i.e., rejected scenarios, protest votes, or non-response); 3) confusion about the correct situations in which to apply WTA; and 4) political unpopularity as politicians won't actually pay compensation (and may not even fund research that says they will). Arguably, the last point applies to WTP too if the payment vehicle is an increase in taxes. In addition, the influential National Oceanic and Atmospheric Administration commissioned report by Arrow et al. (1993) also recommended the use of WTP since it yields estimates that are more conservative.

However, Knetsch (2007) and Whittington et al. (2017) explain that legal entitlements will not always determine the appropriate measure. Rather, the decision about whether to apply WTP or WTA results from the interplay between the status quo situation an individual is actually experiencing and their perceived reference condition, from which they value a change in a good or service (see Whittington et al. (2017) for further information on this and other issues related to applying WTA as part of stated preferences valuation research).[16]

1.3.3. Original Research Approaches to Non-Market Valuation

Several alternative primary valuation techniques have been developed to measure willingness to pay or accept (National Research Council 2005; Freeman et al. 2014). In general, these approaches can be divided into stated and revealed preference techniques with each group containing a variety of alternative techniques. Stated preference approaches involve using surveys to elicit WTP or WTA by observing an individual's choices in a hypothetical market. The main stated preference techniques are the contingent valuation and choice experiment methods. Contingent valuation involves asking survey respondents their WTP or WTA for a single change in an environmental good or service. Choice experiments are similar, though elicit WTP or WTA by asking respondents to choose among several alternative descriptions of the goods or services from which economic values are inferred. Revealed preference techniques involve eliciting WTP and WTA values from observations on an individual's choices or behaviour in actual markets. Multiple techniques fall into this group including a variety of household production function models (e.g., travel cost/random utility models, hedonic pricing, and averting behaviour) and production function models. Travel cost/random utility models estimate WTP by calculating the cost of time and expense incurred for visiting a recreational site (e.g., angling, hiking, swimming, etc.), while hedonic pricing models infer WTP for an environmental resource by linking the price of a marketed good or service, usually property, to its key characteristics at least one of which is the environmental resource. Averting behaviour models, which are applied in the field of health, evaluate WTP by assessing individual expenditures on improving health outcomes or avoiding bad health outcomes. Production function models treat the

[16] Whittington et al. (2017) notes that "…WTA is often the only relevant question" when using stated preferences to elicit values from landowners for modifying their land use to provide ecosystem services as part of PES schemes (which are similar to what my research investigates as part of Theme 1).

environmental resource as an input into the production of a marketed good or service. The value of the environmental resource is estimated by assessing how changes in the resource affect the production of the marketed good or service.

I chose to use choice experiments for my PhD research for several reasons. First, this technique is able to elicit a wider range of economic values than revealed preferences or models based on market prices alone (Flores 2003). Second, it enables me to examine how program characteristics, other than the level of payment, affect willingness to pay or accept (Matta et al. 2009). Finally, an additional output of choice experiment models are market shares (Hensher et al. 2005). Market shares can be used to represent the proportion of individuals or households who would select a certain alternative good or service out of the set of alternatives and is useful for assessing participation in conservation programs.

1.4. A Summary of the Dissertation

Four papers related to the aforementioned topics form the main part of this dissertation, Chapters 2 through 5, and these are followed by a brief conclusion in Chapter 6. In the paper presented in Chapter 2, titled *Landowner Preferences for Wetland Conservation in Two Southern Ontario Watersheds,* I used choice experiments to elicit the preferences of private landowners for wetlands conservation on their land in the Grand and Upper Thames watersheds located in Southwestern Ontario. The motivation for this study stems from an estimated decline of 70% in the extent of the region's wetlands since European colonization. Protecting or restoring wetlands will improve the supply of ecosystem services in the area, notably moderating the impacts of extreme weather and slowing nutrient runoff to Lake Erie. Since private landowners own the majority of land in the two watersheds, they were surveyed to assess their preferences for certain key attributes of voluntary incentive-based wetlands conservation programs using a choice experiment. Two versions of the choice experiment were developed, one tailored to agricultural and forest product producers and another to rural private landowners more generally. Common attributes of the two versions included the land area enrolled in the program, the conservation activity on that land (i.e., conversion to wetland, trees, or meadow), public recognition of landowner conservation actions, and financial compensation. Each version had an additional attribute, with the general landowner version having an offer of technical help attribute and the producer focussed version having a productivity of the enrolled land attribute. Data from the two watersheds were pooled and the two versions were analysed independently using latent class models, which group respondents with similar preferences together into subgroups, from which WTA and participation rates were estimated. The analysis suggests that many private landowners are willing to participate in wetlands conservation at reasonable cost, particularly those who have past participation in incentive-based conservation programs. In general, respondents favoured wetlands conservation programs that divert smaller areas of land to wetlands conservation, target marginal agricultural land, use treed buffers to protect wetlands, offer technical help, and pay financial incentives. Landowners appear reluctant to receive public recognition for their wetland conservation actions.

Chapters 3 through 5 include the papers assessing the validity and reliability of benefit transfer. The paper that forms the third chapter, titled *Transfers of Landowner Willingness to Accept: A Convergent Validity and Reliability Test Using Choice Experiments in Two Canadian Watersheds*, involved testing the reliability and validity of transferring estimates of WTA between the Grand and Upper Thames watersheds. This study was motivated by the apparent lack of any published studies assessing the convergent validity of transfers of WTA, though there are many such studies assessing transfers of WTP. The data for this exercise was taken from the aforementioned choice experiment version tailored to agricultural and forest product producers and was modeled in WTA space using a generalized multinomial logit. The reliability of the transfers were assessed by calculating percent transfer errors and validity was examined by testing the similarity of utility functions and welfare estimates. The results indicate that transfers of WTA are similarly valid and reliable to transfers of WTP already assessed in the literature.

The paper included as Chapter 4, titled *Assessing the Convergent Validity and Reliability of Transfers of Market Shares Derived from Choice Experiments for Landowner Participation in Wetlands Conservation Programs*, involved assessing the validity and reliability of transfers of market shares for landowner participation in the aforementioned wetlands conservation programs (predicted participation in a wetlands conservation program versus maintaining the status quo). Such market shares are derived from choice experiments and are useful for informing policy, though can be costly to obtain via original research which suggests a transfer approach. However, the validity and reliability of transfers of such predicted participation market shares has not been assessed using convergent validity techniques commonly used for benefit transfer assessment, which motivated this paper. To provide context, the validity and reliability of transfers of these market share estimates were compared with a parallel assessment of the validity and reliability of transfers of WTA estimates. Both types of estimates were generated from the general rural landowner choice experiment version discussed previously. Validity and reliability were assessed using the same techniques employed for the paper in Chapter 3. The results clearly show that transfers of predicted participation market shares yield low transfer errors and tolerance levels, especially relative to the parallel transfer of WTA, however whether this validity and reliability is acceptable for policy analysis requires further research.

A paper titled *Reconciling Quantitative Attributes with Different Levels When Transferring Willingness to Pay Elicited from Choice Experiments: Evidence from Benefit Transfers between Four Canadian Watersheds* forms the fifth chapter. Since benefit transfers involve taking value estimates for goods or services from certain sites and transferring them to other sites they usually require the reconciliation of differing good or service definitions. Multiple options for reconciling these differences are available for transfers of values derived from choice experiments, though there is little research examining which options lead to more valid and reliable transfers, providing the motivation for this particular study. Three alternatives for reconciling quantitative choice experiment attributes with levels that differ across sites were assessed, one based on a linear model specification and two based on a quadratic specification. Reconciliation is straightforward for linear relationships since values do not vary. However, reconciling values derived from quadratic relationships is more complicated since values are not constant enabling different reconciliation options. Two such options were assessed as part of this paper including approaches rooted in: 1) ‘relative’ preferences that involve matching levels according to their order in the set of levels; and 2) ‘absolute’ preferences that involve matching levels according to their quantity. The data is from choice experiments that sought the general public’s WTP for changes in four Canadian watersheds (the Little River in New Brunswick; the Humber and Credit Rivers in Ontario; and the Salmon River in British Columbia). Specifically, the choice experiments elicited preferences for improvements in water quality and increases in the proportion of each watershed as protected wildlife habitat, as well as associated declines in local farm and forest product producer income (and an increase in taxes). The levels of the wildlife habitat attribute differed across watersheds, while the levels used for the other attributes were identical. I assessed the validity and reliability of each reconciliation approach using the same techniques as those used in Chapters 3 and 4. Overall, the results suggest that transfers based on the linear specification are more valid and reliable than either quadratic approach for transfers of welfare estimates though not necessarily for marginal estimates. Furthermore, transfers of marginal and welfare estimates based on 'relative' preferences are more valid and reliable than transfers based on 'absolute' preferences. Finally, if the attributes needing reconciliation have more similar levels, the two approaches based on the quadratic specification yield more similar results though only for transfers of welfare estimates.

1.5. Statement of Interdisciplinarity

I believe that the research reported in my dissertation achieves the School of Resource and Environmental Management's requirement of interdisciplinarity for the PhD in Resource and Environmental Management. Two out of three of the School's core disciplines are represented: ecological economics and environmental policy. Furthermore, the research includes elements of the following natural and social sciences outlined in the PhD handbook: water management; conservation biology; and conservation policy.

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Chapter 2.

Landowner Preferences for Wetlands Conservation Programs in Two Southern Ontario Watersheds

A version of this chapter has been published in the Journal of Environmental Management as Trenholm, R., Haider, W., Lantz, V., Knowler, D., and Haegeli, P. "Landowner Preferences for Wetlands Conservation Programs in Two Southern Ontario Watersheds". I led the design of this research and was the lead on the fieldwork. I authored nearly all of the text and conducted all of the data analyses.

Abstract

Wetlands in the region of Southern Ontario, Canada have declined substantially from their historic area. Existing regulations and programs have not abated this decline. However, reversing this trend by protecting or restoring wetlands will increase the supply of important ecosystem services. In particular, these actions will contribute to moderating the impacts of extreme weather predicted to result from climate change as well as reducing phosphorous loads in Lake Erie and ensuing eutrophication. Since the majority of land in the region is privately owned, landowners can play an important role. Thus, we assessed landowner preferences for voluntary incentive-based wetlands conservation programs using separate choice experiments mailed to farm and non-farm landowners in the Grand River and Upper Thames River watersheds. Latent class models were separately estimated for the two data sets. Marginal willingness to accept, compensating surplus, and participation rates were estimated from the resulting models to gain insight into the financial compensation required by landowners and their potential participation. Many of the participating land owners appear willing to participate in wetlands conservation at moderate cost, with more willing groups notably marked by past participation in incentive-based conservation programs. They generally favour wetlands conservation programs that divert smaller areas of land to wetlands conservation, target marginal agricultural land, use treed buffers to protect wetlands, offer technical help, and pay financial incentives. However, landowners appear reluctant to receive public recognition of their wetland conservation actions. Our results are of interest to natural resource managers designing or refining wetlands conservation programs.

Keywords: discrete choice experiment; latent class analysis; willingness to accept; participation rate; agri-environmental programs; wetlands

2.1. Introduction

Wetlands are critically important ecosystems that produce ecosystem services such as water purification and supply, flood control, recreational opportunities, and carbon sequestration that have significant economic value (Zedler & Kercher, 2005; Barbier, 2011; Brander, Brouwer, & Wagtendonk, 2013). Despite their value, the area of wetlands has declined in many parts of the world, including Canada (Mitsch and Hernandez, 2013). The area of wetlands in Southern Ontario, in particular, has decreased significantly and continues to deteriorate. The extent of inland wetlands that are 10 hectares or larger has declined 72% from over 2 million hectares to near 500,000 hectares since European settlement of the region, caused in part by land use change associated with urbanization and agriculture (Ducks Unlimited Canada, 2010). Pressure to convert wetlands is unlikely to abate since the population of Southern Ontario is expected to grow 33% to 17 million by 2041 (Ontario Ministry of Finance, 2014). Furthermore, the functions or distribution of existing wetlands may be altered by a changing climate or invasive species (Mitsch and Hernandez, 2013; Zedler and Kercher, 2004). Though the area of wetlands, and consequently the ecosystem services supplied, has decreased, there is local demand for their conservation (Lantz et al., 2013).

Wetland protection and restoration in Southern Ontario can play a significant role in addressing the local hydrological impacts of climate change and eutrophication of the Great Lakes, particularly Lake Erie. Climate change is expected to result in more intense rainfalls, more frequent high and low streamflows, and increased damages from flooding (Cheng et al., 2012). In certain cases wetlands can alleviate these impacts by storing water, recharging groundwater, and moderating streamflows (Bullock and Acreman, 2003). Lake Erie's eutrophication condition has recently worsened with harmful cyanobacterial algae blooms and hypoxia in its western and central basins, respectively (Joosse & Baker, 2011; Michalak et al., 2013; Scavia et al., 2014). Nuisance *Cladophora* algae blooms regularly occur in the nearshore of the lake's eastern basin (Depew, Houben, Guildford, & Hecky, 2011). Consequently ecosystem health, recreation, drinking water supplies, tourism, and property values have been negatively affected (Joosse & Baker, 2011). Moreover, the harmful algae blooms pose a health risk (Michalak et al., 2013). This eutrophication is thought to be driven mainly by soluble reactive phosphorous loading from non-point sources much of which originates in Southwestern Ontario (Joosse and Baker, 2011; Scavia et al., 2014). Wetland protection and restoration can play a critical role in reducing such phosphorous loading since wetlands are able to remove phosphorous from the water column and retain it or transform it into biologically unavailable forms (Reddy, Kadlec, Flaig, & Gale, 1999; Fisher & Acreman, 2004; Scavia et al., 2014).

As a party to the Ramsar Convention on Wetlands, the Canadian government has an international obligation to conserve wetlands though it shares responsibility for their management with provincial governments. Wetland conservation in the Province of Ontario is embedded in legislation and policies governing land use (Ducks Unlimited Canada, 2010; Rubec and Hanson, 2008). Tax incentive and grant programs are also offered at the federal, provincial, and regional levels (Environment Canada, 2015; Clean Water Program, 2013; Ontario Ministry of Natural Resources and Forestry, 2015a). Other initiatives involve non-governmental organizations such as Ducks Unlimited Canada. Despite these efforts, Southern Ontario's wetland area continues to decline.

Reductions in wetland area can partly be attributed to market failure since few wetland ecosystem services are traded in markets (Barbier, 2011). As such many landowners have no incentive to maintain or restore wetlands and instead convert them to produce marketable goods and services. In an agricultural context, draining wetlands expands the area available for crops and increases the efficiency of field operations (e.g., less turning of farm machinery) (Cortus et al., 2011). Compensating landowners to protect or restore wetlands can provide an incentive to engage in conservation (Hansen et al., 2015). In this case payments should be sufficiently large to induce enough landowners to participate so as to achieve conservation objectives, though be within budgetary constraints. To encourage participation, the incentive should at least cover the opportunity costs of private landowners (Cortus et al., 2011).[17] Several techniques have been used to assess the opportunity cost of conserving wetlands or examine landowner willingness to accept (WTA) for maintaining or restoring them, including hedonic analysis, auctions, simulation, market prices, data from existing programs, and contingent valuation (e.g., Brown et al., 2011; Cortus et al., 2011; Gelso et al., 2008; Hansen et al., 2015; Lawley, 2014; van Vuuren and Roy, 1993; Yu and Belcher, 2011).

[17] However, if landowners benefit from wetlands conservation then the required financial incentive may actually be less compensation than their opportunity cost.

An alternative technique is the choice experiment (CE). CEs are survey-based techniques that are used to assess preferences for key attributes of a good or service (e.g., conservation programs). If one of the attributes is financial then monetary values can be estimated. CEs are able to incorporate a wider range of values than revealed preference techniques, such as hedonic analysis, or other approaches relying on market prices (Flores, 2003). Similarly, CEs can assess preferences for wetland conservation programs that do not exist. Relative to contingent valuation, CEs are able to evaluate how multiple program characteristics affect landowner support for wetlands protection and restoration (Matta et al., 2009). CEs directed at assessing landowner WTA for aspects of conservation programs or land management schemes are becoming common and have been applied in a variety of contexts, including forest management and conservation, biodiversity and endangered species conservation, agri-environmental contracts, water quality protection, and carbon sequestration (e.g., Paulrud & Laitila, 2010; Sorice, Haider, Conner, & Ditton, 2011; Beharry-Borg, Smart, Termansen, & Hubacek, 2013; Greiner, Bliemer, & Ballweg, 2014; Lienhoop & Brouwer, 2015; Peterson, Smith, Leatherman, Hendricks, & Fox, 2015; Vedel, 2015; Villanueva, Gómez-Limón, Arriaza, & Rodríguez-Entrena, 2015). Similarly, Lizin, Passel, & Schreurs, (2015) used a CE to examine the cost of land use restrictions to farmers by assessing their willingness to pay (WTP) for parcels with varying restrictions.

Our main objective is to examine the preferences of Southern Ontario landowners for voluntary incentive-based wetland conservation programs. To do so we use CEs to investigate landowner preferences for certain program characteristics from which we predict WTA and participation rates for alternative program specifications.[18] The remainder of this paper is structured as follows. The study sites are reviewed in Section 2.2. Section 2.3 provides an overview of the method, with details on the choice experiment, data collection, and data analysis. The results are presented in Section 2.4. Finally, the results and policy implications are discussed in Section 2.5. The conclusion follows in Section 2.6.

[18] We could have used WTP, which is often lower than WTA thus yielding more conservative estimates of opportunity cost (Horowitz and McConnell, 2002). However, we chose to use WTA since landowners in Ontario hold the rights to their property and WTA better reflects incentive-based conservation programs. Furthermore, a WTP style question would have its own issues (e.g., landowner WTP to avoid having wetlands constructed on their land may not be realistic).

2.2. Study Sites

The study was conducted in the Grand River and Upper Thames River watersheds (Figure 2.1). At 6,800 km^2, the Grand River watershed is one of the largest in Southern Ontario and the largest Canadian watershed that empties into Lake Erie. The Upper Thames River watershed, also part of the Lake Erie basin, is 3,420 km^2 and drains into Lake St. Clair via the Lower Thames River. Agriculture occurs on 75% and 70% of the Upper Thames and Grand watersheds' land area respectively (Upper Thames River Conservation Authority, 2012; Grand River Conservation Authority, 2014). There are over 6,000 farms in the Grand River watershed and more than 3,500 farms in the Upper Thames River watershed (Grand River Conservation Authority, 2008; Upper Thames River Conservation Authority, 2015). The Grand River watershed is home to around one million residents concentrated in urban areas that cover 7% of its land area and over 500,000 individuals reside in the Upper Thames River watershed with most living in urban areas that cover 10% of its area. Forests, wetlands, and meadows respectively cover 11.3%, 4.8%, and 2.6% of the Upper Thames River watershed. Forests and wetlands cover 20% of the Grand River watershed (Grand River Conservation Authority, 2014; Upper Thames River Conservation Authority, 2012). While the Grand River watershed as a whole meets Environment Canada's (2013) minimum thresholds for wetland area not all of its sub-basins do (Grand River Conservation Authority, 2008) and the Upper Thames River watershed does not.

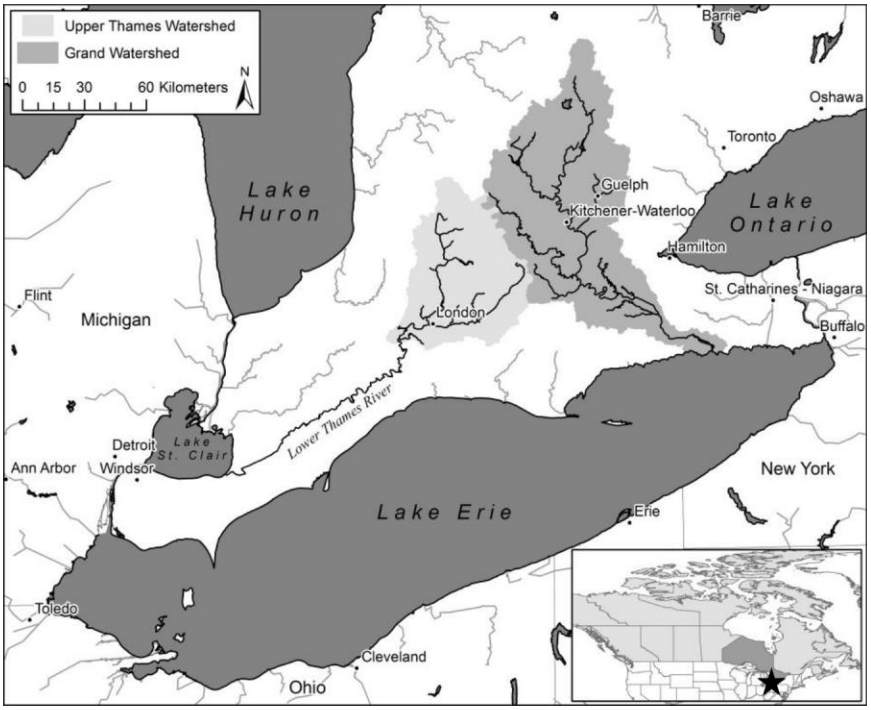

Figure 2.1: The Grand and Upper Thames Watersheds

Urban and agricultural land uses have lowered surface water quality in both watersheds, notably via runoff of phosphorous, nitrogen, and sediment (Grand River Conservation Authority, 2014; Nürnberg & Lazerte, 2015). Phosphorous concentrations exceed provincial objectives (Ontario Ministry of Environment, 2013). The two watersheds are also the main Ontarian contributors of phosphorous to Lake Erie (Lake Erie LaMP, 2011). Climate change is forecast to increase the frequency of extreme rainfall, and consequent flooding, in the two watersheds. Higher flood damage costs are expected to result, especially in larger cities such as London or Kitchener-Waterloo (Cheng et al., 2012). Conservation authorities are actively working to address these issues and recommended actions include wetland retention and restoration (Grand River Conservation Authority, 2014; Nürnberg & Lazerte, 2015).

2.3. Method

2.3.1. The Choice Experiment

The choice experiment surveys used in this study were based on questionnaires first implemented in the Credit River watershed, located immediately east of the Grand River watershed, during spring 2012 (Trenholm et al., 2013). These original surveys, targeted at agricultural landowners, were developed after a literature review coupled with feedback from landowners (via several focus groups) and the local watershed conservation authority. An important outcome from the focus groups was the necessity to have separate, but similar, CEs for farm and rural non-farm landowners that differed in a few attributes and levels (Table 2.1). Certain attributes targeted at farm landowners were not sensible for those who do not farm their land or have smaller land holdings. In addition non-farm landowners participating in the focus groups had lower expectations for financial compensation. We created the non-farm CE by altering the original farm version so that the attributes better correspond to the anticipated situations and motivations of rural non-farm landowners: the 'area converted' levels were made smaller; the 'type of land converted' attribute was dropped in favour of 'technical assistance'; and the 'payment to landowner' levels were lowered and were no longer per acre. Non-CE questions were identical across the farm and non-farm versions. For the present study, we used the same CEs, but the non-choice experiment questions were slightly modified based on insight gained during their initial implementation and feedback from the Grand River and Upper Thames River conservation authorities.

The rationale for each attribute follows. We included the 'type of land to be converted' attribute to account for differences in the agricultural productivity of land diverted to wetlands conservation. The 'conversion activity' attribute was included to assess preferences for diverting land directly to wetland or to trees or meadow to help retain nearby wetlands. The latter two levels act as critical function zones, adjacent upland areas with biophysical functions and characteristics directly related to wetlands, or protection zones which are upland areas of natural vegetation that protect wetland ecosystem functions (Environment Canada, 2013). We included the 'area converted' attribute to examine preferences for the amount of land diverted to wetlands conservation. The smaller acreages included were more palatable to focus group participants and small-scale wetlands can produce many ecosystem services (Blackwell and Pilgrim, 2011). We included ‘technical assistance’ and ‘public recognition’ attributes in order to assess preferences for non-financial compensation and examine whether their inclusion in an incentive-based wetlands conservation program could reduce the required payment. ‘Technical assistance’, which is a feature of certain stewardship programs in Ontario (Conservation Ontario, 2013), was only included in the non-farm CE since non-farm focus group participants were more interested in this type of compensation than farm participants. ‘Public recognition’ was of interest to the conservation authority partner and was identified as important by some focus group participants. Finally, the ‘payment to landowner’ attribute was included to assess preferences for financial compensation and to allow estimation of WTA.

Table 2.1: Attributes and levels for the farm and non-farm choice experiments

Attribute	Variable Name	Levels	
		Farm	Non-Farm
Type of land to be converted *Land can be productive or marginal (i.e., less fertile, sloping, etc.) farmland*	Land Type	Marginal Productive	*N/A*
Conversion activity *Land can be converted to meadow or trees to help retain nearby wetlands, or directly into wetland*	Meadow Trees Wetland	Meadows Trees Wetland	Meadows Trees Wetland
Area converted *Area of land to be converted*	Acres	1.0 acre 3.0 acres 5.0 acres	0.5 acres 1.0 acre 1.5 acres
Technical assistance *Technical advice from experts, the government or other groups involved*	Technical	*N/A*	No Yes
Public recognition *Signage on property, stewardship banquets, and awards are provided*	Recognition	No Yes	No Yes
Payment to landowner *Annual payment to the landowner*	Payment	$50 per acre $150 per acre $250 per acre $350 per acre $450 per acre $550 per acre	$0 $50 $100 $150 $200 $250

.

Macros in SAS 9.3 software were used to create a main effect fractional factorial design with 72 alternatives grouped into 36 choice sets and allocated among 6 blocks (Kuhfeld, 2010). The resulting design was used for both choice experiments, but independently modified to address dominant alternatives yielding final farm and non-farm designs with D-efficiencies of 92%, and 91 %, respectively.

The following preamble, describing the wetlands conservation program, appeared at the beginning of the choice experiment (version administered in the Upper Thames is the same):

> Suppose that in an effort to enhance and restore wetlands within and adjacent to the Grand River watershed, the government offered a voluntary program that provided incentives (e.g., payments, public recognition) to landowners to set aside some of their lands. This land could be (i) converted to meadow or trees to help retain nearby wetlands; or (ii) converted directly into wetlands if appropriate.

This was immediately followed by program conditions, including: 1) a contract length of 5 years; 2) the possibility of renewing the contract after 5 years; 3) any land set aside is in addition to existing commitments and legal requirements; and 4) that the government covers any capital and material costs.[19] Instructions on how to complete the choice task were then provided along with information on each attribute. A cheap talk script aimed at reducing hypothetical bias appeared next (Ladenburg & Olsen, 2014). It read "Please consider the options carefully – as if you were entering into a real contract with the government – since the program would have a limited budget and could only fund a limited number of projects". The 6 choice sets were then presented (Figure 2.2).

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Type of land to be converted	Marginal	Marginal	---
Conversion activity	Wetland	Meadow	---
Number of acres	5 acres	3 acres	---
Public recognition	Yes	No	---
Annual payments to you	$450/acre	$450/acre	$0/acre
Please choose only one	☐	☐	☐

Figure 2.2: An example of a choice set from the farm version
Note: the non-farm version appears similar

[19] We initially used a contract length of 10 years but focus group participants felt that this was too long given their planning horizon. Five years, with the possibility to renew, was deemed more acceptable.

After each choice set, respondents were asked to indicate how certain they were about their selection on a scale from 1 to 10. (Norwood, 2005; Brouwer, Dekker, Rolfe, & Windle, 2010; Ready, Champ, & Lawton, 2010). Finally, respondents were asked the primary reason for their choices at the end of the CE to allow screening for protests (Meyerhoff et al., 2014).

2.3.2. Data Collection

The surveys were administered by mail using Canada Post's Unaddressed Admail™ (Canada Post, 2015). This service has been used in other studies to survey Canadian farmers (e.g., Yu & Belcher, 2011; Anderson & McLachlan, 2012). Routes in postal codes and forward sortation areas which were at least 70% within each watershed's boundaries were selected. All identified routes were surveyed except for the non-farm survey in the Grand watershed where a random sample of identified routes was surveyed. The farm version was sent to 8,004 farm households on 181 rural and suburban routes while 10,086 houses on 77 rural routes were sent the non-farm version. In partnership with the Grand River and Upper Thames River conservation authorities, surveys were simultaneously administered to both watersheds during the months of April and May 2013. Households were initially sent a survey package containing a cover letter, a questionnaire, and a postage paid return envelope. One week later reminder/thank you postcards were sent out and two weeks after that a second survey package was mailed. Respondents were invited to complete a ballot to be entered into a draw for a $100 Visa gift card (we maintained anonymity by separating ballots from questionnaires when returned).

Surveys returned from non-targeted postal codes or forward sortation areas were removed from further analysis. Respondents repeatedly selecting the same answer for all Likert-style questions were deemed serial non-participants and removed. Similarly, those choosing the same non-status quo option for all 6 choice sets were also removed since it is unlikely that this response pattern reflects genuine preferences. Finally, respondents selecting the status quo option for all 6 choice sets and whose answers to the follow-up questions suggested they were protesting were also dropped (Meyerhoff et al., 2014).[20]

2.3.3. Data Analysis

Our data analysis was divided into three stages (Figure 2.3). The first stage of our analysis involved contrasting sociodemographic and land characteristics from both surveys with each other and with farm operator and rural population data. Whether the characteristics differed significantly across the two samples was assessed using Pearson chi-squared tests for categorical data and t-tests for continuous data in SPSS 23 software. Whether the samples differed from the population was evaluated via binomial tests for binomial data, Pearson chi-squared tests for categorical data, and t-tests for continuous data. Since respondents were not asked directly to self-identify as farmers or foresters we used farming and forestry related questions to create an indicator of whether a respondent is engaged in agriculture or forest production on their land. This was accomplished in SPSS 23 by first conducting a non-linear principal components analysis (Linting and van der Kooij, 2012).[21] The resulting components were clustered via SPSS's two-step clustering procedure yielding a binary variable.

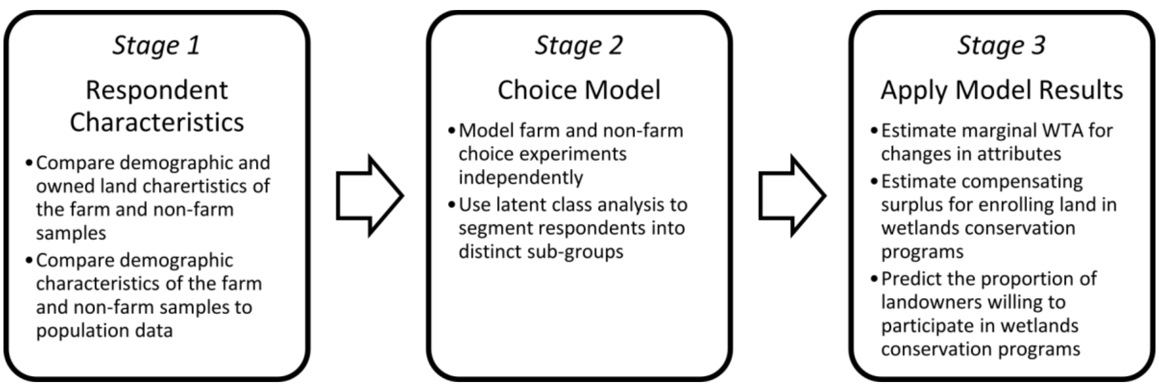

Figure 2.3: The three stages of our data analysis

The second stage of our analysis involved modeling the CE data. We used latent class analysis to model the utility functions for each choice experiment (the econometric

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[20] We identified protesting respondents as those selecting "I don't trust the government" or providing an open-ended answer suggesting they did not state their true preferences.

[21] The following variables were entered into the principal components analysis: ownership of at least 100 acres of land (dummy); primary land use is agriculture or forestry (dummy); generated income from their land in past 5 years via agriculture or forestry (dummy); land features agricultural land cover (dummy); percentage of income from on-farm sources (ordinal); and membership in a farming or woodlot organization (dummy).

model is reviewed in Appendix A). Latent class models group respondents with similar preferences together to account for preference heterogeneity (preferences are homogeneous within classes, but vary across classes). While other approaches account for preference heterogeneity (e.g., random parameters logit), latent class models provide better insight into how the wetland conservation program's impacts are distributed since it identifies distinct groups of respondents (Boxall and Adamowicz, 2002). To determine the number of classes we initially estimated several models that differed according to the number of classes and then selected the model yielding the lowest information criterion (Louviere et al., 2000). Akaike's (AIC) and Bayesian (BIC) information criteria are often used (Akaike, 1974; Schwarz, 1978). We chose the BIC since it is better at determining the number of classes (Nylund et al., 2007).

Following Johnston and Duke (2008), the utility functions were specified to include interactions between the attributes that characterize the conserved land and the acres attribute (Equations 2.1a and 2.1b for the farm and non-farm CEs, respectively).[22] For the farm choice experiment, the acres attribute was interacted with the type of land set aside and the conversion activity. Area converted was only interacted with the conversion activity for the non-farm choice experiment. This allows the impacts of land type or conversion activity on landowner utility to vary by the area conserved. These interactions also ensure that land type and conversion activity do not impact utility when no acres are conserved. Utility also varies by class s.

$$\mathrm{V^s} = \alpha^s(\mathrm{ASC}) + \beta_1^s(\mathrm{Acres}) + \beta_2^s(\mathrm{Acres})(\mathrm{Land\ Type}) + \beta_3^s(\mathrm{Acres})(\mathrm{Wetland}) + \beta_4^s(\mathrm{Acres})(\mathrm{Trees}) + \beta_5^s(\mathrm{Recognition}) + \beta_6^s(\mathrm{Payment\ per\ Acre}) \tag{2.1a}$$

$$\mathrm{V^s} = \alpha^s(\mathrm{ASC}) + \beta_1^s(\mathrm{Acres}) + \beta_2^s(\mathrm{Acres})(\mathrm{Wetland}) + \beta_3^s(\mathrm{Acres})(\mathrm{Trees}) + \beta_4^s(\mathrm{Technical}) + \beta_5^s(\mathrm{Recognition}) + \beta_6^s(\mathrm{Payment}) \tag{2.1b}$$

[22] Though these interactions were not in the initial design, correlations and variance inflation factors indicate that collinearity is inconsequential.

The alternative specific constant (ASC) was set to one for 'Program A' or 'Program B' and zero for 'No Program'. The numerical attributes 'acres conserved' and 'payment attributes' were coded according to their actual levels. The binary attributes 'public recognition' and 'technical help' were dummy coded with the parameter set to one when present and zero when absent. The categorical attributes 'land type' and 'conversion activity' were effects coded. The functional form and coding scheme allow the ASC parameter to represent utility when zero acres are conserved and no technical help, public recognition, or payment are received.

The farm and non-farm CEs were analyzed independently in Latent Gold Choice 5.0 (Vermunt and Magidson, 2005). Following Beck, Rose, & Hensher (2013), each choice was weighted by respondent certainty using Latent Gold's replication weights. Variables representing respondent characteristics, known as covariates, were included to predict class membership.[23] Certain respondents could not participate in some of the alternatives since their owned land area is less than the acre attribute level (those owning between 1 and 5 acres for the farm survey or 0.5 and 1.5 acres for the non-farm survey). Rather than remove them from the sample, losing any insight into their preferences, they were segmented into their own known class and a latent class analysis performed on the remaining respondents. Models with 1 to 4 latent classes and the full complement of covariates were estimated for both CEs (covariates significant at 10% were retained).

The third stage of our analysis involved applying the choice model. The resulting model parameters were used to derive estimates of marginal WTA for changes in each attribute, which involves taking the negative of a ratio of partial derivatives (Matta et al., 2009). For example, the marginal WTA of class s for public recognition is calculated via Equation 2.2.

$$\mathrm{WTA}^{s}_{\text{Public recognition}} = -\frac{\partial V^{s}/\partial \text{Recognition}}{\partial V^{s}/\partial \text{Payment}} = -\frac{\beta^{s}_{5}}{\beta^{s}_{6}} \qquad (2.2)$$

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[23] Variables representing personal characteristics (female, age in years, post-secondary education, employed, and midpoint of household income categories), land characteristics (forest cover, meadow cover, wetland cover, acres owned in watershed, succession plan, midpoint of years since land obtained), and other characteristics (Grand watershed, farm or forest producer, participated in an existing incentive-based conservation program, and distance of respondent's postal code centroid from the nearest major city). All covariates are dummy variables unless otherwise indicated.

In addition, we examined the share of landowners predicted to participate in different wetlands conservation program specifications versus the status quo using a decision support tool (Hensher et al., 2005). The impact on landowner welfare was also assessed via mean compensating surplus (CS). Following Hanemann (1984), CS for changes from the baseline (V_0^s) to a given program (V_1^s) can be estimated for class s following Equation 2.3.

$$CS^s = -\frac{(V_0^s - V_1^s)}{\beta_6^s} \tag{2.3}$$

2.4. Results

The rate of survey returns, including fully and partially completed questionnaires, was 17.0% (1,713 surveys) for the non-farm survey and 19.2% (1,535 surveys) for the farm survey. After accounting for missing data, returns from non-targeted postal codes, serial non-participants, protest responses, and those owning less land than the lowest acre attribute levels only 9.6% (n = 968) of the non-farm surveys and 10.7 % (n = 856) of the farm surveys sent out were used.[24]

2.4.1. Respondent Characteristics

Aside from age, demographics differed significantly across the two versions with farm respondents more likely to be male, employed, and have lower incomes compared to non-farm respondents, though less likely to have a post-secondary degree (Table 2.2). Both the farm and non-farm samples were significantly more likely to be male and older compared to the farm operator and rural populations, respectively. Additionally, the farm sample was significantly more likely than the farm operator population to hold a post-secondary degree, while the non-farm sample was significantly more likely to hold a post-secondary degree than the farm operator and rural populations. The farm sample was significantly more likely to be employed relative to the rural population. Income also

[24] These rates are at the low end of those from similar CEs in Europe or North America which range from 10.5%, in the case of Rossi et al. (2011), to 87% for Sorice et al. (2011). However, they are within the range of 1.71% to 33% reported by surveys that have used Canada Post's Admail service to contact farmers and other Canadian farmer surveys (e.g., Shaikh et al., 2007). Regardless, if non-respondent preferences are substantially different from respondent preferences then the low rate may result in non-response bias potentially making it difficult to extrapolate results to the wider population of landowners. One could conservatively assume that non-respondents are not willing to participate in the wetlands conservation programs.

differed significantly with farm and non-farm respondents on average reporting higher incomes than the population of farm operators, but lower incomes than the rural population.

Table 2.2: Respondent socio-demographic characteristics (% unless otherwise indicated)

Respondent Characteristics	Data Type	Survey			Farm Operators[a]		Rural Population[b]	
		Farm (1)	Non-Farm (2)	Tests (3)	Estimate (4)	Tests (5)	Estimate (6)	Tests (7)
Gender								
Male	Binary	77.2	65.1	***	70.8	†††	50.4	†††
Female		22.8	34.9		29.2		49.6	
Age (Adults)								
Under 35	Categorical	7.9	7.5		10.6	†††	24.4	†††
35 to 54		38.9	38.5		44.6		39.3	
55 or older		53.2	53.9		44.8		36.3	
Mean (years)	Continuous	54.9	55.4		52.9	†††	41.1	†††
Highest level of education[c]								
Not post-secondary	Binary	47.5	34.5	***	85.6	†††	52.1	‡‡‡
Post-secondary		52.5	65.5		14.4		47.9	
Employment status								
Not in labour force	Categorical	19.3	28.6	***			29.0	§§§
Unemployed		1.1	1.4				2.1	
Employed		79.7	69.9				68.9	
Household Income								
Under $50,000	Categorical	22.9	19.9	**	28.8	†††	16.6	†††
$50,000 to $74,999		22.3	20.5		20.6		16.3	
$75,000 to $99,999		23.6	21.4		16.9		24.5	
$100,000 and over		31.2	38.2		33.7		42.7	

*** and ** indicate farm (1) and non-farm (2) sample estimates differ at the 1% and 5% level of significance.

††† farm (1) and non-farm (2) sample estimates differ from the population estimate (4 or 6) at the 1% level of significance.

‡‡‡ non-farm sample estimate (2) only differs from the population estimate (6) at the 1% level of significance.

§§§ farm sample estimate (1) only differs from the population estimate (6) at the 1% level of significance

[a] Farm operator population data from the 2011 Census of Agriculture (Statistics Canada, 2012a) for census consolidated subdivisions intersecting with the two watersheds in the case of gender and age. Education and household income are at the provincial level.

[b] Rural population data from the 2011 Census of Population (Statistics Canada, 2012b) or the 2011 National Household Survey (Statistics Canada, 2013) for dissemination areas intersecting with the two watersheds.

[c] Data on farm operators represents those with and without a university degree, while survey data and rural population data represent those with or without a post-secondary degree or diploma.

Testing suggests that, other than having a succession plan, land characteristics differed significantly across the two surveys (Table 2.3). Farm survey respondents were more likely to have: each type of land cover; agriculture as a primary land use; generated income from their land; earned higher portions of their income from farming; larger land holdings; obtained land earlier; and participated in an incentive-based conservation program.

Table 2.3: Respondents' land characteristics (% unless otherwise indicated)

Characteristic	Data Type	Farm	Non-Farm	Tests
Land Cover				
Has forests	Binary	57.9	47.0	***
Has meadows	Binary	22.5	19.2	*
Has wetlands	Binary	48.6	43.2	**
Has crop, pasture, or orchard (i.e., agricultural land cover)	Binary	84.7	56.5	***
Land Use				
Primary land use is agriculture	Categorical	72.3	39.4	***
Primary land use is forestry		0.7	0.7	
Primary land use is residential		25.4	57.3	
Generated income from land in past 5 years	Binary	79.0	47.8	***
Portion of household income from farming				
0%	Categorical	23.2	55.2	***
1 % to 24 %		27.0	23.5	
25 % to 49 %		13.9	5.6	
50 % to 74 %		10.3	3.5	
75 % to 99 %		13.6	5.0	
100 %		12.0	7.3	
Area of Land Holdings				
< 10 acres	Categorical	15.7	45.4	***
10 =< 70 acres		21.4	25.2	
70 =< 130 acres		32.7	15.0	
130 acres =<		30.3	14.5	
Mean (acres)	Continuous	136.7	68.0	***
Year First Obtained Land in the Region				
Before 1970	Categorical	18.0	11.4	***
1970 to 1980		16.0	12.9	
1981 to 1990		22.1	19.6	
1991 to 2000		19.5	21.2	
2001 to 2006		12.6	15.9	
2007 to 2013		11.3	18.8	
Succession plan for land	Binary	72.3	72.8	
Participated in conservation program with incentive or cost-share payments	Binary	31.1	18.4	***

***, **, and * indicate farm and non-farm sample estimates differ at the 1%, 5%, and 10% level of significance

Two groups of respondents resulted from the principal components analysis and clustering of farm and forestry related questions — those more and less likely to be agricultural or forest producers. The bulk of farm survey respondents were likely to be engaged in agriculture or forestry (71.5 %), though a sizable minority of non-farm respondents were similarly engaged (36.4 %).

2.4.2. Choice Models

The BIC indicates that the model with 3 latent classes and 1 known class represents the data the best for both versions of the CE (Tables 2.4 and 2.5). In both cases the means of the posterior class membership probabilities indicate decent classifications (all 0.79 or larger).

Farm Model

The known class contains 98 respondents while the modal class sizes are 370, 222, and 166 for latent classes 2, 3, and 4, respectively. Members of the known class favor converting fewer acres of their land to wetland conservation. They prefer if this area is marginal rather than productive and is converted to trees relative to wetlands, and wetlands over meadows. They favor larger amounts of compensation. The ASC and public recognition parameters are insignificant. Respondents in this class are significantly more likely to be post-secondary graduates and female relative to those in latent class 4 (the base), though significantly less likely to have forests or wetlands on their land and to be an agricultural or forest producer.

Class 2's ASC parameter suggests that they strongly prefer participating in a wetlands conservation program over maintaining their status quo all else equal. They prefer if less of their land is set aside for conservation and would rather if this area is marginally productive and converted to trees, followed by meadow, and wetland. They favor larger incentive payments and dislike public recognition. Relative to those in class 4, respondents in class 2 are significantly more likely to be older, female, and hold a post-secondary degree, though they are less likely to be farm or forest producers. While their likelihood of having participated in an existing cost-share or incentive-based conservation program is similar to class 3, they are significantly more likely to have done so than class 4.

Class 3's ASC parameter suggests that they prefer their status quo to participating in a wetlands conservation program all else equal. They prefer converting their land to trees, followed by meadow, and then wetland. They also favor larger payments. Class 3's acres, land type, and public recognition parameters are insignificant. Members of class 3 are significantly more likely to be post-secondary graduates and live further from large cities relative to class 4, but less likely to be farm or forest producers. While their likelihood of participation in an existing cost-share or incentive-based conservation program is similar to class 2, they are significantly more likely than class 4 to have participated.

Class 4's ASC parameter suggests that, all else equal, they strongly favour their status quo situations over enrolling in a wetlands conservation program. They prefer to divert smaller marginally productive areas of their land to conservation. Members of this class prefer larger incentive payments and dislike public recognition. The conversion activity parameters are all insignificant. Class 4 is the covariate reference group, though relative to the two latent classes they are less likely to have a post-secondary degree and to have participated in a cost-share or payments-based conservation program, though more likely to be farm or forest producers.

Table 2.4: Model for the farm survey

Variable	Known Class 1[a]	Latent Classes[a]		
		Class 2	Class 3	Class 4
		Attributes		
ASC	0.2225	1.4377***	-0.8728***	-3.3984***
	(0.2297)	(0.1954)	(0.3291)	(0.5148)
Acres	-0.1039**	-0.0818**	0.0050	-0.2018**
	(0.0491)	(0.0339)	(0.0442)	(0.0992)
Acres*Land Type	-0.1632***	-0.2613***	-0.0031	-0.2807***
(Productive)	(0.0258)	(0.0236)	(0.0260)	(0.0669)
Acres*Wetland	-0.0246	-0.0632***	-0.1597***	-0.0140
	(0.0316)	(0.0217)	(0.0267)	(0.0593)
Acres*Trees	0.0886***	0.1170***	0.0919***	0.0635
	(0.0315)	(0.0215)	(0.0255)	(0.0564)
Acres*Meadow	-0.0639**	-0.0538***	0.0679**	-0.0495
	(0.0309)	(0.0208)	(0.0292)	(0.0532)
Recognition (Yes)	-0.1508	-0.1848*	0.0884	-0.5908**
	(0.1543)	(0.1053)	(0.1671)	(0.2694)
Annual payment	0.0011**	0.0010***	0.0069***	0.0045***
per acre	(0.0005)	(0.0004)	(0.0007)	(0.0009)
		Covariates		
Intercept	1.5387	-0.8431	0.2823	Base
	(0.9560)	(0.6605)	(0.7082)	
Age in years	0.0005	0.0243***	-0.0091	
	(0.0144)	(0.0087)	(0.0099)	
Post-Secondary	1.1506***	0.7611***	1.4455***	
	(0.3765)	(0.2374)	(0.2841)	
Gender (Female)	0.6943*	0.5585*	0.5150	
	(0.4173)	(0.3052)	(0.3489)	
Forest cover	-1.2656***	0.1608	-0.3010	
	(0.4018)	(0.2458)	(0.2881)	
Wetland cover	-1.9659***	0.0277	-0.1903	
	(0.3982)	(0.2356)	(0.2771)	
Conservation	0.7824	0.7599***	0.7930***	
Payment	(0.5437)	(0.2546)	(0.2910)	
Producer	-8.5166***	-0.6613**	-0.7020*	
	(2.3989)	(0.3218)	(0.3669)	
Distance from city	0.0299	0.0035	0.0254*	
(KM)	(0.0205)	(0.0130)	(0.0147)	
Modal class size	98 (11.4%)	370 (43.2%)	222 (25.9%)	166 (19.4%)
Mean of posterior	1.00	0.84	0.80	0.92
probabilities (S.D.)	(0.00)	(0.15)	(0.16)	(0.15)
Log-likelihood	-3284.25			
BIC (AIC)	6,939.87 (6,678.49)			
ρ^2 (overall)	0.3993			

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively

[a] Standard errors appear in brackets below the corresponding coefficient

Non-Farm Model

The known class contains 215 respondents while the modal class sizes are 415 for latent class 2, 177 for latent class 3, and 161 for latent class 4. The known class favors converting smaller areas of their land to trees relative to meadow and meadow relative to wetland. They also prefer receiving technical help and larger payments. Their ASC and public recognition parameters are insignificant. Members of this class are significantly more likely to have a lower household income, be located in the Grand watershed, and to live close to a large city relative to class 4, though they are significantly less likely to have forest or wetlands on their land, be farm or forest producers, and to have participated in an incentive-based conservation program.

Class 2's ASC parameter suggests that, all else equal, they are inclined to participate in a wetlands conservation program rather than maintain their status quo. They prefer converting their land to trees, followed by wetland, and then meadow. Technical help and larger incentive payments are favored by class 2, though they dislike receiving public recognition for their conservation efforts. Class 2's area parameter is insignificant. Relative to class 4, class 2 is significantly more likely to have a lower household income and to have wetland cover on their land.

Class 3's ASC parameter indicates that they favour maintaining their status quo situations over enrolling in a wetlands conservation program all else equal. They prefer to convert smaller areas of their land and appear to favor wetland or tree cover over meadow. Members of class 3 like receiving technical help. Their public recognition and payment parameters are insignificant. In comparison to class 4, respondents in class 3 are significantly more likely to have a lower household income, owned their land for longer, live closer to a large city, and have wetlands on their land, but are less likely to have participated in an existing incentive-based conservation program.

Class 4's ASC parameter suggests that, all else equal, they prefer participating in a wetlands conservation program over maintaining their current situations. Members of this class strongly favor converting fewer acres but prefer if this area is treed, followed by meadow, and distantly wetland. They favour receiving technical help, dislike public recognition, and prefer larger payments. Class 4 forms the covariate reference group, though relative to the two latent classes this class is more likely to have higher household incomes and less likely to have wetland cover on their land.

Table 2.5: Model for the non-farm survey

Variables	Known Class 1[a]	Latent Classes[a]		
		Class 2	Class 3	Class 4
		Attributes		
ASC	-0.1061	0.8918***	-1.9572***	0.5431**
	(0.1684)	(0.1944)	(0.4141)	(0.272)
Acres	-0.2970**	0.1054	-1.4519***	-1.6110***
	(0.1297)	(0.1025)	(0.3543)	(0.4735)
Acres*Wetland	-0.2439***	0.0723	0.3337	-2.6943***
	(0.0683)	(0.0772)	(0.2151)	(0.6027)
Acres*Trees	0.3822***	0.3936***	0.2615	2.0638***
	(0.0631)	(0.0606)	(0.2092)	(0.3751)
Acres*Meadow	-0.1383**	-0.4658***	-0.5952**	0.6305**
	(0.0669)	(0.0628)	(0.2535)	(0.3751)
Technical help (Yes)	0.2842***	0.7844***	0.6669***	0.5787***
	(0.1073)	(0.0963)	(0.2647)	(0.1669)
Recognition (Yes)	-0.1552	-0.2034**	-0.3848	-0.3404*
	(0.0993)	(0.0821)	(0.2528)	(0.1788)
Annual payment	0.0014**	0.0073***	0.0018	0.0054***
	(0.0006)	(0.0006)	(0.0016)	(0.0011)
		Covariates		
Intercept	2.7209***	1.7553**	0.6440	Base
	(0.7574)	(0.697)	(0.7371)	
Household income ($1,000s)	-0.0142**	-0.0106**	-0.0112**	
	(0.0061)	(0.0054)	(0.0056)	
Watershed (Grand)	0.5526*	-0.4022	0.1635	
	(0.3004)	(0.2966)	(0.3003)	
Land obtained	-0.0117	-0.0016	0.0192*	
	(0.0111)	(0.0103)	(0.0106)	
Forest cover	-1.5334***	0.3597	-0.0144	
	(0.3495)	(0.2885)	(0.2930)	
Wetland cover	-1.2943***	1.0773***	0.7333**	
	(0.3696)	(0.2861)	(0.2997)	
Conservation payment	-2.5432**	-0.0273	-0.8594**	
	(1.0494)	(0.3134)	(0.3649)	
Producer	-5.0562***	-0.3896	-0.3214	
	(0.9859)	(0.2819)	(0.2896)	
Distance from city (KM)	-0.0511***	0.0072	-0.0380**	
	(0.0164)	(0.0148)	(0.0171)	
Modal class size	215 (22.2%)	415 (42.9%)	177 (18.3%)	161 (16.6%)
Mean of posterior probabilities (S.D.)	1.00	0.91	0.94	0.79
	(0.00)	(0.14)	(0.12)	(0.16)
Log-likelihood	-3911.80			
BIC (AIC)	8,201.74 (7,933.60)			
ρ^2 (overall)	0.3768			

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively

[a] Standard errors appear in brackets below the corresponding coefficient

2.4.3. Applying Choice Model Results

Marginal Willingness to Accept

All statistically significant mean marginal WTA values appear sensible (Table 2.6). Positive and negative marginal estimates, respectively, increase and decrease the total amount of compensation required by farm and non-farm respondents. This compensation generally increases with the number of acres conserved, when this area is productive or is converted to wetlands or meadows, and when public recognition is provided. The required compensation generally decreases if the area conserved is marginal or converted to trees and when technical help is provided. However, classes do value attributes differently — for the same attribute some classes have a marginal WTA that is not significantly different from $0, while other classes have significant marginal WTA that is positive or negative. For example, in the case of the farm CE converting land to meadows significantly increases the compensation required by class 2 though decreases it for class 3 and such an action does not significantly impact the compensation required by classes 1 or 4. In addition, the magnitudes of the marginal estimates differ across classes. The values are generally larger for farm classes 1 and 2 as well as non-farm classes 3 and 4 (though class 3's marginal values are all insignificant). In sum this means that the compensation required by some classes is larger than that required by other classes.

Table 2.6: Mean marginal WTA per year (2013 $CAD)

Attribute	Farm[a]				Non-Farm[a]			
	Known	Latent Classes			Known	Latent Classes		
	Class 1	Class 2	Class 3	Class 4	Class 1	Class 2	Class 3	Class 4
Acres (one acre)	98.37* [-16.31 to 213.05]	78.92* [-1.69 to 159.53]	-0.73 [-13.31 to 11.85]	45.26* [-6.37 to 96.89]	210.25* [-25.50 to 446.00]	-14.43 [-42.18 to 13.31]	785.53 [-587.42 to 2,158.48]	296.32*** [105.46 to 487.18]
Acres*Land Type (Productive)	154.53** [26.79 to 282.27]	252.27*** [67.99 to 436.54]	0.45 [-6.97 to 7.88]	62.95*** [19.97 to 105.92]	*Not applicable*			
Acres*Land Type (Marginal)	-154.53** [-282.27 to -26.79]	-252.27*** [-436.54 to -67.99]	-0.45 [-7.88 to 6.97]	-62.95*** [-105.92 to -19.97]				
Acres*Wetland	23.31 [-39.00 to 85.62]	60.99** [6.64 to 115.33]	23.21*** [14.69 to 31.73]	3.15 [-22.60 to 28.89]	172.69* [-0.63 to 346.01]	-9.90 [-30.27 to 10.47]	-180.54 [-555.98 to 194.90]	495.57*** [228.28 to 762.85]
Acres*Trees	-83.83* [-175.16 to 7.50]	-112.96** [-201.77 to -24.16]	-13.35*** [-21.02 to -5.68]	-14.24 [-37.51 to 9.04]	-270.60** [-520.00 to -21.21]	-53.90*** [-72.8 to -34.99]	-141.48 [-486.52 to 203.56]	-379.59*** [-558.95 to -200.24]
Acres*Meadow	60.52 [-15.01 to 136.06]	51.97* [-5.68 to 109.63]	-9.86** [-18.28 to -1.43]	11.09 [-12.36 to 34.54]	97.91 [-30.17 to 226.00]	63.80*** [46.35 to 81.24]	322.02 [-302.35 to 946.39]	-115.98** [-218.82 to -13.13]
Technical help (Yes)	*Not applicable*				-201.22* [-404.44 to 2.00]	-107.42*** [-132.85 to -81.99]	-360.80 [-1,005.19 to 283.59]	-106.45*** [-178.08 to -34.81]
Recognition (Yes)	142.74 [-188.57 to 474.05]	178.42 [-85.11 to 441.95]	-12.84 [-59.63 to 33.95]	132.51* [-1.87 to 266.88]	109.85 [-62.83 to 282.53]	27.85** [4.94 to 50.76]	208.18 [-276.63 to 693.00]	62.61* [-4.25 to 129.47]

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Significance assessed via Wald tests with standard errors estimated using the delta method.

[a] 95 % confidence intervals, estimated via the delta method, in square brackets.

Compensating Surplus and Predicted Participation

The lowest (L) and highest (H) predicted participation rates and the associated program specifications appear in Table 2.7 alongside the corresponding CS estimates. For the known classes the acres attributes were constrained to their lowest levels due to the small area of respondent land holdings. The lowest (highest) predicted participation rates correspond to the highest (lowest) CS estimates observed. Additionally, with the exception of the acre attribute, the highest (lowest) participation rates occur when attributes are set at their most (least) preferred levels.[25]

Direct comparisons across classes using upper and lower bounds are difficult since the bounds often result from different program specifications. However, it is evident that the two known classes are willing to participate and for reasonable compensation despite their smaller land holdings. Indeed, for both known classes the CS estimates corresponding to the program specifications yielding the highest participation rates are negative. High participation rates can also be achieved for farm latent classes 2 and 3 as well as for non-farm latent classes 2 and 4. The CS estimates indicate that these groups require relatively low compensation compared to farm class 4 and non-farm class 2.

[25] While counterintuitive, since diverting larger areas of land to conservation is disliked by most classes, the interaction of this attribute with the land type or conversion activity attributes leads to situations where the disutility associated with the higher acreage is offset by gains in utility from the land type or conversion activity attributes. The outcome depends on the relative size of the coefficients. When the land type or conversion activity coefficients are larger than the acres coefficient, such as when the attributes are at their preferred levels, classes will favour diverting more land rather than less (given the levels used in the CEs). Non-farm class 3 is the exception since their acres coefficient is larger in magnitude than their conversion activity coefficients.

Table 2.7: Bounds on Participation (%) and Compensating Surplus (2013 $CAD)

		Farm Survey								
		Acres	**Land Type**	**Activity**	**Recognition**	**Payment**	**Participation (%)[a]**		**CS ($/acre/year)[a]**	
Known	L	1	Productive	Meadow	Yes	$50	62	[53/71]	246	[-77/568]
Class 1	H	1	Marginal	Trees	No	$550	84	[78/89]	-351	[-973/272]
Class 2	L	5	Productive	Wetland	Yes	$50	49	[38/61]	752	[193/1,310]
	H	5	Marginal	Trees	No	$550	98	[98/99]	-2,819	[-5,056/-583]
Class 3	L	5	Productive	Wetland	No	$50	35	[20/50]	241	[162/321]
	H	5	Marginal	Trees	Yes	$550	99	[98/99]	41	[-53/135]
Class 4	L	5	Productive	Meadow	Yes	$50	0	[0/1]	1,491	[884/2,098]
	H	5	Marginal	Trees	No	$550	61	[43/80]	603	[416/789]
		Non-Farm Survey								
		Acres	**Technical Help**	**Activity**	**Recognition**	**Payment**	**Participation (%)**		**CS ($/year)**	
Known	L	0.5	No	Wetland	Yes	$0	54	[47/61]	376	[108/645]
Class 1	H	0.5	Yes	Trees	No	$250	78	[73/83]	-156	[-434/121]
Class 2	L	1.5	No	Meadow	Yes	$0	70	[61/79]	-20	[-79/34]
	H	1.5	Yes	Trees	No	$250	99	[99/100]	-332	[-417/-251]
Class 3	L	1.5	No	Meadow	Yes	$0	1	[0/2]	2,928	[-1,925/7,847]
	H	0.5	Yes	Wetland	No	$250	33	[19/47]	1,001	[-527/2,550]
Class 4	L	1.5	No	Wetland	Yes	$0	0	[-1/2]	1,151	[525/1,729]
	H	1.5	Yes	Trees	No	$250	98	[97/99]	-331	[-518/-141]

[a] 95 % confidence intervals, estimated via the delta method, in square brackets.

We separately plotted participation rates and CS against all possible program specifications by class to better compare the latent classes. Participation rates vary substantially and certain classes are more receptive to certain specifications (Figure 2.4). For the farm CE, classes 2 and 3 had higher rates than class 4 in all cases. Class 2's participation rate was higher than class 3's for more than half of the specifications — generally when smaller areas are conserved, the land type is marginal, the conversion activity is wetland or trees instead of meadow, and the payments lower. For the non-farm CE, class 2 had the highest participation rate for all specifications. The majority of class 4's participation rates were higher than class 3's, predominantly when smaller areas are conserved and the conversion activity is meadow or trees (class 4's predicted participation plummets when the conversion activity switches from trees to wetland).

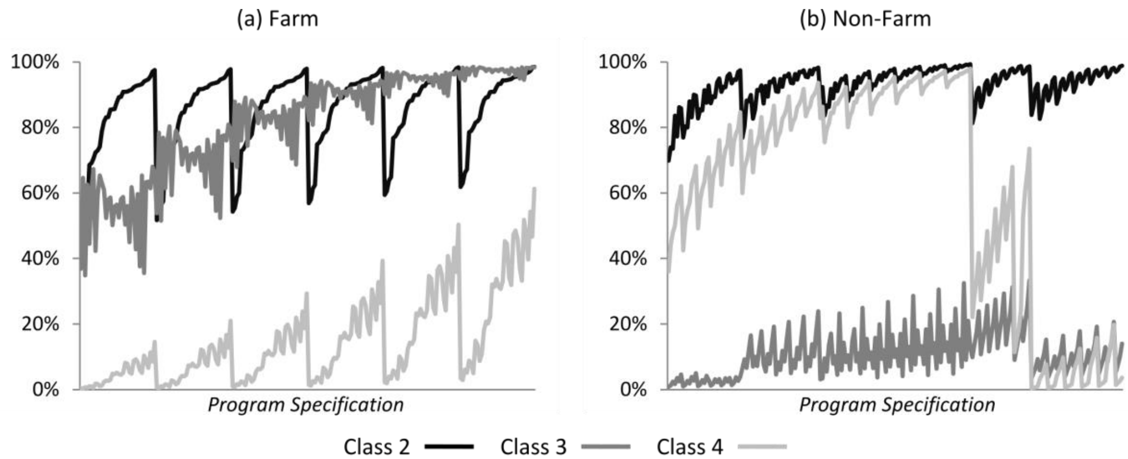

Figure 2.4: Participation Rates for all Possible Program Specifications by Latent Class

CS also varies substantially by program specification and certain classes require less compensation than others (Figure 2.5).[26] In terms of the farm CE, class 4 has the highest CS for all specifications and most of class 3's estimates are larger than class 2's. The signs on the estimates suggest that classes 3 and 4 require compensation for their participation, and that class 2 often does not. For the non-farm CE, class 3 has the highest CS for all specifications and class 4's estimates are larger than class 2's in all but one case (though many of their estimates are similar). The signs on their estimates suggest that class 2 may not require payment to participate in all specifications, while

[26] We used Wald tests employing standard errors estimated via the delta method to assess significance. Most of the farm CS estimates are significant, as are those of non-farm classes 2 and 4. However, all of non-farm class 3's estimates are insignificant.

class 3 requires compensation in all cases as does class 4 for the majority of specifications.

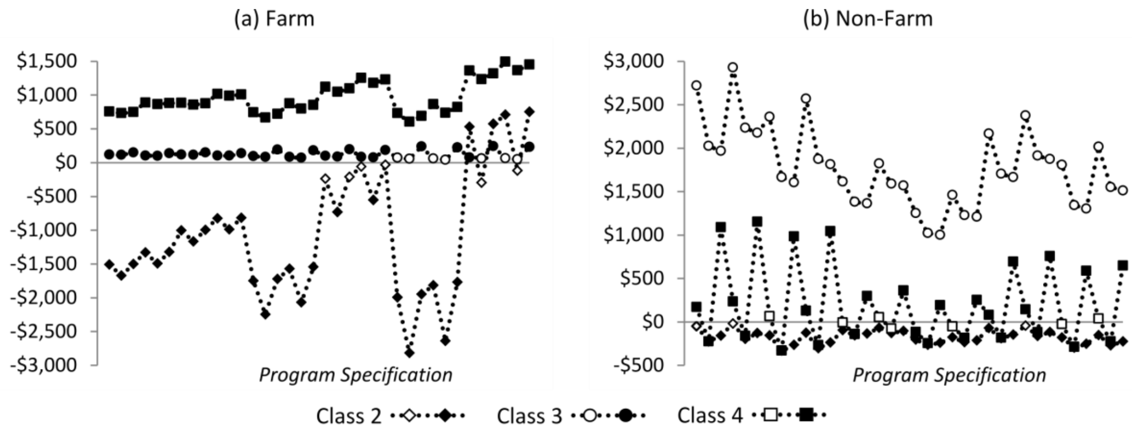

Figure 2.5: Compensating Surplus for all Possible Program Specifications by Latent Class

Note: estimates differing significantly from $0 at 10% significance have solid markers while insignificant estimates have empty markers

2.5. Discussion

The results indicate that conservation programs similar to those examined may help reverse the decline of southwestern Ontario's wetlands since many farm and rural non-farm landowners in the Grand and Upper Thames watersheds appear willing to participate in such programs. However, the latent class analysis suggests that landowner preferences for such schemes are heterogeneous, with certain groups more willing to participate than others, a finding consistent with similar analyses (e.g., Sorice et al., 2011; van Putten et al., 2011; Broch & Vedel, 2012; Beharry-Borg et al., 2013; Villanueva et al., 2015).

Preferences for common attributes are consistent across both CEs. In all significant cases both sets of respondents dislike converting larger areas of their land as in Schulz et al. (2014), Lienhoop & Brouwer (2015), and Villanueva et al. (2015), which is sensible since this constrains land use. Farm class 3 and non-farm class 2 were not sensitive to the acres attribute, but these two groups did care about the cover to which these acres were converted. Indeed, with the exception of farm class 4, respondents to both CEs expressed significant preferences for at least one type of cover with trees favored followed by meadow or wetlands depending on the CE and class. Thus creating critical function or protection zones around existing wetlands appears more preferable than restoring or creating new wetlands. The preference for trees may reflect their relative amenity value or that their benefits have been emphasized through local reforestation programs (Tracy Ryan, personal communication, November 19, 2014). Wetlands in rural regions have also been found to be disamenities that negatively impact property prices potentially because they harbour mosquitoes that are vectors for diseases such as the West Nile Virus and limit land use (Bin and Polasky, 2005). Meadows provide habitat for bobolinks and eastern meadowlarks whose presence limits land use since their habitat is protected in Ontario (Ontario Ministry of Natural Resources and Forestry, 2015b). Indeed, mosquitoes and limits to property development were identified as drawbacks of wetlands during our focus groups as was the presence of endangered species. Public recognition was largely disliked, though the negative coefficients for both known classes and latent class 3s were insignificant. Landowners may have concerns about privacy and worry that the public would be more likely to access their land. All farm and non-farm classes prefer larger incentive payments. However, non-farm class 3 does not appear concerned about financial compensation.

Farm survey respondents generally favor conserving marginal land instead of productive land which is logical since by definition marginal land has less value than productive land. However latent class 3 does not appear concerned about the difference in land values. This class is less likely to contain forest or agricultural producers than the reference class raising the prospect that the land type attribute did not apply to their situations. All groups of non-farm respondents viewed technical help favourably, reflecting the results of Espinosa-Goded et al. (2010), Sorice et al. (2011), and Lienhoop & Brouwer (2015).

While many marginal WTA estimates are positive (e.g., acres), indicating that respondents require compensation for the associated program characteristic, several are negative (e.g., tree cover) implying that respondents would pay. In isolation, this can be interpreted as not requiring compensation, however for the conservation program as a whole it means that such characteristics reduce the size of the incentive-payment required. Though our estimates of marginal WTA vary by attribute, class, and CE they are comparable with those from similar landowner choice experiments (e.g., lump-sum marginal WTA estimated by Broch & Vedel (2012) from their latent class model ranged from -€1621 to €3644 per acre (-$2,749 to $6,180 in 2013 CAD)). Though the evaluated wetlands programs, conservation practices, and valuation techniques are different, our

WTA estimates are also in the range of those resulting from studies evaluating WTA or the costs to farmers of wetlands conservation (e.g., low of $1.72 per acre ($1.96 2013 CAD) in Gelso et al. (2008) to a high of $6116 per acre ($6170 2013 CAD) in Hansen et al. (2015)).

2.5.1. Policy Implications

Whether to protect or restore wetlands in the Grand and Upper Thames watersheds depends largely on resulting changes to ecosystem services. Not all wetlands provide every ecosystem service (Zedler, 2003) and service provision may vary temporally (Maltby and Acreman, 2011), while some services may never be restored (Zedler and Kercher, 2005). However, there is evidence that wetlands created, restored, or maintained as part of federal incentive programs in the Midwestern United States have reduced nitrogen, phosphorous, and sediment runoff as well as increased carbon sequestration (Fennessy & Craft, 2011; Marton, Fennessy, & Craft, 2014). It can take a while to realize improvements, which conflicts with the 5 year horizon of our CE (Zedler and Kercher, 2005). Although, our CE's contract was renewable so longer term participation is possible (Hansen et al. (2015) note the USDA's Conservation Reserve Program had a 50% renewal rate from 2009-2013 with non-renewing landowners not necessarily draining restored wetlands).[27]

From an economic perspective, if the benefits of improvements in ecosystem services outweigh the costs then it is worthwhile to proceed with wetlands protection and restoration. Brander et al. (2013) found annual per acre mean values of wetlands in agricultural landscapes of $2,803 for flood control, $1,372 for water supply, and $2,343 for nutrient cycling ($3,311, $1,621, and $2,769 in 2013 CAD). Furthermore, Lantz et al. (2013) observed that households in and near the Credit River watershed, just east of the Grand watershed, were willing to pay from $34.49 to $1,060.70 annually ($36.90 to

[27] While the 5 year contract length makes it less likely that the benefits of wetland improvements are fully realized before the contract ends, longer contracts were rejected by landowners attending the focus groups. Furthermore, a follow-up question after the CE revealed that just over 50% of farm and non-farm respondents to this question prefer 5 year contract lengths and only 20% prefer 10 years. Such feedback suggests that a shorter contract length would lead to higher participation resulting in more wetlands being restored or protected for a shorter period, while a longer contract length would lead to lower participation resulting in fewer wetlands being restored or protected for a longer period. However, renewable contracts mean that wetlands conservation could be sustained for longer periods. How different contract lengths impact wetlands benefits over time requires more research.

$1,134.95 in 2013 CAD) to retain or restore wetlands. While a benefit-cost analysis is beyond the scope of this research and our WTA estimates only account for landowner opportunity cost, a basic comparison of our compensating surplus estimates with these benefit estimates hints that protecting or restoring wetlands in our study region is worthwhile.

To increase the likelihood that benefits outweigh costs, wetland conservation programs can be designed to encourage landowner participation at least cost. Or results suggest that landowner participation can be increased and the costs imposed on them lessened if:

- smaller areas of land are diverted to conservation purposes, notably for less favoured land covers such as meadows or wetland;
- marginal rather than productive land is targeted for conservation;
- expert technical advice is provided; and
- wetlands are protected or enhanced with treed buffers instead of meadows or restored directly.

Certain conservation programs already incorporate these features (e.g., USDA's Wetland Reserve Easement). On the other hand, programs should not provide public recognition as landowners appear reluctant to participate or even require higher compensation if it is offered. Finally, while larger incentive payments can increase participation, this is limited by budgetary constraints.

Similar to Sorice et al. (2011) and Broch & Vedel (2012), our results imply that tailoring programs to subgroups of relatively willing landowners may reduce costs. Assuming our samples are representative enough and depending on the program specification, landowners sharing the characteristics of farm latent classes 2 or 3 should be targeted, while for the non-farm group efficiencies can be achieved by targeting landowners sharing the characteristics of latent class 2 and in certain cases latent class 4 (see Table 2.8 for a summary of each class). The two known classes, containing respondents with small land holdings are also fairly willing to participate and for relatively low cost. Our results also indicate that respondents in the farm known class and latent class 2 as well as the non-farm known class and latent classes 2 and 4 would be willing to pay to participate in many program specifications, which likely means that they would do so for little or no compensation.

Table 2.8: Summary of Class Characteristics and Keys to Increasing Participation

	Known Class 1	Class 2	Class 3	Class 4
		Farm Survey		
Member Characteristics (Relative to Class 4)	More likely… ▪ post-secondary degree Less likely… ▪ wetlands on land ▪ forest on land ▪ farm or forest producer	More likely… ▪ post-secondary degree ▪ older ▪ female ▪ participant in existing incentive-based program Less likely… ▪ farm or forest producer	More likely… ▪ post-secondary degree ▪ further from larger cities ▪ participant in existing incentive-based program Less likely… ▪ farm or forest producer	Reference group
Increasing Participation	▪ Smaller area ▪ Marginal land ▪ Trees>Wetland>Meadow ▪ Higher payment	▪ Smaller area ▪ Marginal land ▪ Trees>Meadow>Wetland ▪ No public recognition ▪ Higher payment	▪ Trees>Meadow>Wetland ▪ Higher payment	▪ Smaller area ▪ Marginal land ▪ No public recognition ▪ Higher payment
		Non-Farm Survey		
Member Characteristics (Relative to Class 4)	More likely… ▪ low household income ▪ in Grand watershed ▪ close to large cities Less likely… ▪ wetlands on land ▪ forest on land ▪ farm or forest producer ▪ participant in existing incentive-based program	More likely… ▪ low household income ▪ wetlands on land	More likely… ▪ low household income ▪ own land longer ▪ close to large cities ▪ wetlands on land Less likely… ▪ participant in existing incentive-based program	Reference group
Increasing Participation	▪ Smaller area ▪ Trees>Meadow>Wetland ▪ Technical help ▪ Higher payment	▪ Trees>Wetland>Meadow ▪ Technical help ▪ No public recognition ▪ Higher payment	▪ Smaller area ▪ Wetland>Trees>Meadow ▪ Technical help	▪ Smaller area ▪ Trees>Meadow>Wetland ▪ Technical help ▪ No public recognition ▪ Higher payment

For targeting to be feasible, the subgroups must be identifiable (Broch and Vedel, 2012). Perhaps the best and most convenient indicator of willingness to participate is past involvement in an incentive-based conservation program, though not in the case of the known classes. Targeted payments could also be controversial since participants would be paid different amounts and in some cases nothing. Potentially less controversial would be to target groups of landowners with education or outreach activities. Even if targeting landowners is feasible the benefit of protecting or restoring wetlands on their properties should be considered — if the least cost opportunities yield relatively low societal benefit then targeting may not be worthwhile.

2.6. Conclusion

Despite certain limitations, such as the relatively low response rate and short contract period used in the CEs, we believe that our research adds to the literature. We build upon studies estimating the costs of wetlands conservation to private landowners by using CEs to assess landowner preferences for wetland conservation programs from which we estimate their WTA and predict their participation. A chief advantage of CEs is that they allow an assessment of how landowners trade-off different aspects of wetlands conservation programs yielding better insight into landowner preferences than methods used in existing studies. For instance, most respondents favoured diverting land to trees, followed by either meadow or wetlands suggesting that creating new or restoring former wetlands is less appealing than protecting or enhancing existing wetlands. This research also builds upon similar CEs in the literature, most notably by including public recognition of conservation actions as an attribute. Respondents generally disliked such recognition despite its use by conservation organizations (e.g., easement signage). We also surveyed non-commodity producing rural landowners in addition to agriculture and forest product producing landowners who are often engaged as part of similar CEs. Our results indicate that wetlands conservation programs should not be limited to commodity producers as many other landowners are willing to protect or restore wetlands.

Our results also confirm many findings from previous studies. The segmentation resulting from the latent class model suggests that private landowners have heterogeneous preferences for conservation schemes and that certain groups are more receptive to participating than others. Consequently, tailoring programs to groups of landowners who are more willing to participate and receptive to lower incentive payments can lead to program efficiencies. Though preferences were heterogeneous, we found that landowners generally dislike diverting larger areas of their land to conservation purposes though favour receiving technical help and financial compensation, similar to the results of existing research. Finally, the marginal WTA and CS estimates derived from our model are in the range of those estimated as part of previous landowner CEs and studies assessing the costs of wetland conservation to private landowners.

In sum, given the attributes and levels used in the CEs, our results show that many private landowners in Southern Ontario’s Grand and Upper Thames River watersheds are willing to participate in wetlands conservation though participation depends on the characteristics of the program. This is especially true for those who have already participated in an incentive-based conservation scheme. We also provide guidance to resource managers on how to design new wetlands conservation programs or modify existing schemes to increase landowner participation and reduce costs imposed on them (and thus compensation). Notably, wetlands conservation programs in the region should allow diversion of smaller areas to conservation purposes, target marginal agricultural land, protect existing wetlands with treed buffers, offer technical help and not public recognition, and use financial incentives.

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Chapter 3.

Transfers of Landowner Willingness to Accept: A Convergent Validity and Reliability Test Using Choice Experiments in Two Canadian Watersheds

A version of this chapter has been published in the Canadian Journal of Agricultural Economics as Trenholm, R., Lantz, V., Haider, W., and Knowler, D. "Transfers of Landowner Willingness to Accept: A Convergent Validity and Reliability Test Using Choice Experiments in Two Canadian Watersheds". I led the design of this research and was the lead on the fieldwork. I authored nearly all of the text and conducted all of the data analyses.

Abstract

We examined the reliability and validity of transferring estimates of marginal willingness to accept and compensating surplus. In doing so we used data from two case studies applying choice experiments to elicit landowner preferences for incentive-based wetland conservation programs in two adjacent watersheds in Southern Ontario, Canada (Grand and Upper Thames Rivers in parallel in 2013). The choice experiment data was modeled in willingness to accept space using a generalized multinomial logit. Transfer reliability was investigated by calculating transfer errors, while validity was investigated by testing the equality of utility functions as well as by assessing the similarity in welfare estimates using traditional hypothesis tests and equivalence tests. The main findings are that transfers of willingness to accept are similar to existing transfers of willingness to pay in terms of validity and reliability. Additionally, a sensitivity analysis finds that including demographic variables in the choice model can lead to lower transfer validity though does not substantially affect reliability. Though further research is required, our results suggest that willingness to accept can be transferred as part of policy analyses.

Keywords: benefit transfer; convergent validity; transfer error; tolerance level; willingness to accept; compensating surplus; choice experiment; willingness to accept space; wetlands

3.1. Introduction

Benefit-cost and cost-effectiveness analyses often require values for non-market goods and services that are obtained using stated or revealed preference methods. However, these original research based techniques can be expensive and time consuming (Brouwer, 2000). When funds and time are scarce it may be advantageous to use benefit transfer to obtain non-market values. Benefit transfer involves transferring existing values or functions from one or more sites, known as the study sites, to the location of the current analysis, known as the policy site. Unit value and function transfers are the two main approaches to benefit transfer (Boyle et al., 2010). Unit value transfer involves transferring welfare estimates from the study site(s) to the policy site. Benefit function transfer involves transferring models relating observable respondent or site characteristics to welfare estimates. Meta-analysis is an additional technique, similar to function transfer, which combines multiple studies into a single function.

Though benefit transfer is relatively inexpensive, there are concerns about its accuracy, which is affected in part by generalization errors resulting from transfers across space, time, or populations (Johnston and Rosenberger 2010). Rosenberger (2015) summarizes transfer errors from 38 convergent validity studies published from 1992 to 2012 that assess transfers of willingness to pay (WTP). Errors range from 0% to 7496% for value transfer, with a mean and median of 140% and 45%, respectively. Similarly, the range is 0% to 929% for function transfer with a mean of 65% and median of 36%. Rosenberger (2015) also summarizes validity test results finding that 55% of tests of model coefficients reject the null hypothesis of equal parameters, while 44% of tests of WTP values reject the null hypothesis of equal estimates.

One of the main findings of the convergent validity literature is that generalization error can be reduced by increasing the geographic similarity of study and policy sites. For example, transfers conducted within subnational jurisdictions/regions or between like countries are more accurate, as are those between communities sharing common experiences/attitudes or with similar environmental characteristics (Loomis 1992; Loomis et al. 1995; VandenBerg et al. 2001; Brouwer and Bateman 2005; Jiang et al. 2005; Johnston 2007; Johnston and Duke 2009; Czajkowski and Ščasný 2010; Bateman et al. 2011). However, evidence from other studies such as Chattopadhyay (2003) and Colombo & Hanley (2008) suggests that transfers between similar sites does not reduce generalization error, while Johnston & Duke (2009) note that spatial proximity is not sufficient for transfer validity. Finally, the results of Morrison & Bergland (2006) indicate that transfers across different sites and populations are largely reliable and valid, but that transfers across geographic scales are not. Choice model specification, for instance via the inclusion of respondent characteristics, may also influence transfer validity and reliability (Brouwer et al. 2015), though Ostberg et al. (2013) find similar transfer performance for a specification with easily available respondent characteristic variables and a statistically driven specification with more variables. Finally, Bateman et al. (2011) note the effect of site similarity varies by transfer approach. When sites are similar, unit value transfer results in less transfer error than function transfer and when sites are dissimilar, function transfer performs better.[28]

To our knowledge, all of the published studies assessing reliability and validity of benefit transfers across space, time, and populations have used estimates of WTP.[29] Transfers may also be used to estimate willingness to accept (WTA) and source studies for input into such transfers are increasingly available (e.g., Matta et al. 2009; Yu and Belcher 2011; Broch and Vedel 2012; Lienhoop and Brouwer 2015; Hansen et al. 2018). For certain policy analyses, WTA is theoretically more appropriate than WTP for measuring a change in economic welfare (Knetsch 2007). The two measures differ in their reference levels of utility (Freeman et al. 2014; Whittington et al. 2017). Using WTP when WTA is the appropriate measure could result in incorrect policy decisions since the measures will not necessarily be identical with WTA often exceeding WTP for the same good, in many cases by a large margin (see Horowitz and McConnell (2002), Tunçel and Hammitt (2014), or Kim et al. (2015) for overviews). As outlined by Kim et al. (2015), there are several possible explanations for this disparity, including: substitution effects; incentive compatibility; commitment cost; bounded rationality; value and institutional learning; salience; as well as reference dependence and loss aversion (prospect theory).

[28] The temporal reliability and validity of transfers have also been assessed by examining the stability of models or values over time (e.g., Brouwer and Logar 2014; Rigby et al. 2016; and Price et al. 2017).

[29] Several stated preference valuation studies have elicited landowner WTA concurrently at multiple sites or regions, though none test transfers. Most have found evidence that WTA differs by region or soil zone (Gasson & Potter, 1988; Lohr & Park, 1995; Shaikh, Sun, & van Kooten, 2007; Paulrud & Laitila, 2010; Espinosa-Goded, Barreiro-Hurlé, & Ruto, 2010). However, Shaikh et al. (2007) and Yu & Belcher (2011) found that WTA does not differ by region or soil zone, respectively. Since these studies were not designed to test transfers they provide limited insight into the validity and reliability of transfers of WTA.

While it is well documented that WTA often exceeds WTP, the disparity between the two measures does not guarantee disparate transfer validity or reliability. However, it is conceivable that the cause of the disparity in the two measures differs by site so that the validity and reliability of transfers of WTA or WTP differs. Consider reference dependence and loss aversion, which Kim et al. (2015) note is the prevailing explanation for the gap between the two measures. Their impact could differ across two sites such that the difference in the marginal utilities of a gain between sites could be less, or more, than the difference in the marginal utilities of a loss. There is evidence that loss aversion differs by gender, education, and income (Booij and van de Kuilen 2009; Booij et al. 2010). Similarly, Wang et al. (2017) find that loss aversion differs across cultures, while Maddux et al. (2010) find that the gap between WTP and WTA varies across cultures. Thus, if study and policy sites differ substantially — for instance in terms of demographic or cultural makeup — then loss aversion or the endowment effect could also differ resulting in the validity and reliability of WTA transfers diverging from that of transfers of WTP. If sites are fairly similar then we would expect less disparity in the validity and reliability of transfers of these two measures.

Not all research finds a significant disparity in the WTP and WTA measures and the particulars of such findings could inform when transfers of the two measures have more similar validity and reliability (if WTP≈WTA then transfers of these measures should have the same validity and reliability). For instance, List (2003, 2004, 2011) has shown in a series of experiments that there is no disparity between WTP and WTA for individuals with market experience. Additionally, a recent meta-analysis by Tunçel and Hammitt (2014) confirms that market experience reduces the disparity and also finds a smaller disparity for ordinary private goods relative to non-market or public goods, among other findings.[30] Thus, we would expect the validity and reliability of transfers of WTA to be more similar to that of transfers of WTP if the values being transferred are elicited for goods more similar to ordinary market goods or from individuals with more market experience.

Motivated by the lack of research into the validity and reliability of transfers of WTA and the increasing availability of source studies for such transfers, our study's main objective is to investigate the reliability and validity of transferring marginal WTA and

[30] Knetsch (2007) observes that the reduced disparity between WTP and WTA for those with market experience is expected, having been noted in Kahneman et al. (1990).

compensating surplus (CS) estimates. To do so, we relied on case studies in two neighbouring watersheds in Southern Ontario, Canada that used choice experiment surveys to elicit landowner WTA for enrolling their land in wetland conservation programs (these case studies focussed on farm and forest product producers). Since the two study sites are similar and adjacent we expect the disparity in WTP and WTA to be constant across the two sites (i.e., no differences in loss aversion). Furthermore, as the survey's focus is on farm and forest product producers, a group with market experience, we anticipate that WTA likely approaches WTP which narrows the disparity in the validity and reliability of the two measures. Additionally, according to Whittington et al. (2017) the good being valued is essentially a private good from the perspective of landowners, which also works to narrow the gap between WTP and WTA. Given these points, we test the hypothesis that transfers of WTA between the two sites are similarly valid and reliable to transfers of WTP that have been assessed already in the convergent validity literature. Our empirical assessment contributes to the literature in light of the recent surge in primary valuation studies using WTA, especially those that elicit these values from landowners, that increases the availability of source studies for benefit transfer. Left unassessed, applied benefit transfer practitioners have little guidance about whether transfers of WTA are desirable. In the remainder of this paper we review the data and methods in Section 3.2, present the results in Section 3.3, and finish with a discussion and conclusion in Section 3.4.

3.2. Data and Methods

Choice experiments are a survey-based stated preference technique used to elicit an individual's preferences for aspects of goods or services (Hoyos 2010). Goods or services are described in terms of the levels taken by their key attributes and several alternative profiles are generated. Respondents are asked to choose their favorite profile from a set of alternative profiles, which forces them to trade-off the attributes of the good or service, and this data is used to infer their preferences. The technique can be used for non-market valuation if one of the attributes is monetary. In the following sections, we describe the choice experiment data and the various analysis steps — analysis of choice data, derivation of WTA and CS, and testing of transfer reliability and validity — in detail. Choice experiments are common in benefit transfer testing, though Kaul et al. (2013) find that they may result in larger transfer errors relative to other techniques.[31] However, this technique generates values for marginal changes, which makes it suitable for benefit transfer (Morrison and Bergland 2006).

3.2.1. Data

We implemented the case study choice experiments in Southern Ontario's Grand River and Upper Thames River watersheds in 2013 (Figure 3.1). These watersheds are part of the Great Lakes Basin with the Grand emptying into Lake Erie directly, and the Upper Thames into Lake Erie via Lake St. Clair. The region is densely populated and home to 11 million residents (Ontario Ministry of Finance, 2014). The area of wetlands in the region has declined by around 72% since European colonization (Ducks Unlimited Canada 2010).

[31] Kaul et al. (2013) advise that this finding may only reflect the studies included in their meta-analysis and that it does not provide insight on each technique's ability to predict actual values at the policy sites.

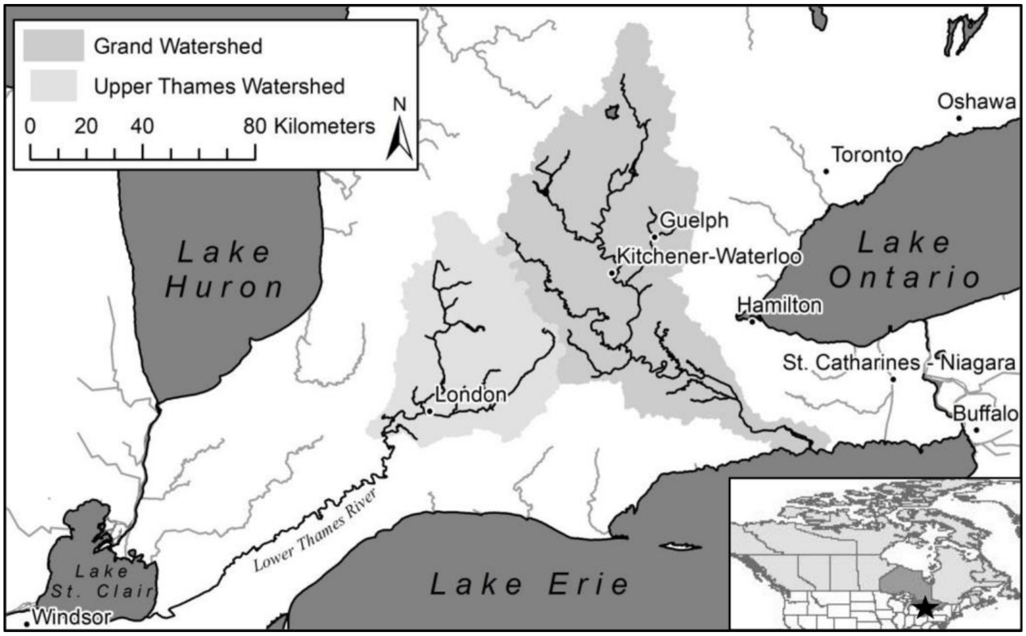

Figure 3.1: Location of the Grand and Upper Thames Watersheds

The Upper Thames watershed is about half the size of the Grand watershed (Table 3.1). Though the Grand and Upper Thames watersheds are home to large populations, agriculture is the dominant land use in both. The forest and wetland cover in the Grand watershed is larger than in the Upper Thames watershed. However, the Grand watershed has almost no meadow cover while the Upper Thames watershed has 3%. The average price of farmland in the Grand watershed is higher than in the Upper Thames.

Table 3.1: Characteristics of Each Watershed

Characteristic[a]	Grand	Upper Thames
Area (km^2)	6800	3420
Population		
Urban area (%)	6	10
Population	970,000	515,640
Population Density (#/km^2)[b]	143	150
Agriculture		
Agriculture area (%)	70	75
Farm Count	6000	3500
Farm Density (#/km^2)[b]	0.88	1.02
Average Farm size (ac)[c]	201	233
Farmland Price Per Acre[d]	$16,500	$11,000
Land Cover		
Forest area (%)	19	11
Wetlands area (%)	10	5
Meadow area (%)	<1	3

[a] Unless otherwise indicated, information on the Grand is from Grand River Conservation Authority (2008, 2014, 2016), and on the Upper Thames from Upper Thames River Conservation Authority (2012, 2015).

[b] Population and farm densities were calculated by the authors.

[c] Average farm size estimated by authors using Statistics Canada data (Statistics Canada 2012).

[d] Average of prices per acre in nearest markets (RE/MAX 2013).

The choice experiment surveys sought to estimate the preferences of private landowners — particularly farmers — located in and near the two watersheds for restoring and protecting wetlands. They were part of a larger research program and were initially used in the neighbouring Credit River watershed in 2012. We consulted the literature and obtained feedback from landowners over several focus groups as well as from members of the local conservation authority during the survey's initial development. After its initial implementation we made changes to the questionnaire guided by insight gained from surveying Credit watershed landowners and from members of the Grand and Upper Thames conservation authorities. The Grand and Upper Thames River questionnaires were identical and the choice experiments were identical in content and appearance (see Table 3.2 for an overview of the attributes and Appendix B1 for a copy of the choice experiment up to the first choice set). Further details on each study are available in Trenholm et al. (2017).The same main effects fractional factorial design was used for both choice experiments. We used SAS 9.3 software to generate 72 alternatives, group them into 36 choice sets along with a status quo alternative, and allocate these sets among 6 blocks (Kuhfeld 2010). We then made a few changes to reduce dominance, resulting in a final D-efficiency of 92.4%.

Table 3.2: Attributes and Levels used in the Choice Experiments in Both Watersheds

Attribute	Variable Name	Description	Levels	Coding
Area converted	Acres	Area of land converted to wetlands conservation	1 acre 3 acres 5 acres	Numerically coded using actual values
Type of land to be converted	Land Type	Land can be productive or marginal (i.e., less fertile, sloping, etc.)	Marginal Productive	Effects coded
Conversion activity	Meadow Trees Wetland	Land can be converted to meadow or trees to help retain nearby wetlands, or directly into wetland	Meadows Trees Wetland	Effects coded
Public recognition	Recognition	Signage on property, stewardship banquets, and awards	No Yes	Dummy coded (No = 0; Yes = 1)
Payment to landowner	Payment	Annual payment per acre	\$50 \$150 \$250 \$350 \$450 \$550	Numerically coded using actual values

We used a mixed coding scheme for the variables representing each attribute (Table 3.2). Effects codes were used to ensure that the 'type of land converted' and 'conversion activity' attributes are not aliased with the alternative specific constant (ASC). Thus, the ASC parameter represents landowner utility when no acres of their land are converted to wetlands and no public recognition or payment is offered.[32]

We administered the questionnaires by mail to farm households using Canada Post's Unaddressed Admail service in conjunction with each watershed's conservation authority (Canada Post 2015). During the spring of 2013, we sent the choice experiment to 4600 and 3404 farm households in the Grand River and Upper Thames watersheds, respectively. There were 921 and 601 respondents to the Grand and Upper Thames

[32] We investigated models with interactions between the area converted and land type attributes as well as area converted and conversion activity attributes and even conducted the convergent validity assessment using these models. However we do not report these results since the interactions are not built into the experimental design. Regardless, the results of the transfer assessments are fairly similar.

surveys, respectively. After data cleaning 531 observations remained in the Grand and 362 in the Upper Thames.[33]

3.2.2. Econometric Model

Following Glenk et al. (2015), who modeled their input into benefit transfer assessment in WTP space, we model our data in WTA space. Compared to models in preference space, those in WTA space generate more reasonable and efficient welfare estimates with known distributional properties (Thiene and Scarpa 2009). To illustrate the model in WTA space, it is useful to first review the random parameters logit (RPL) model in preference space. Following Train (2009), the utility individual *n* gains from consuming alternative *j = 1, 2, 3,…, or J* on choice occasion *t* can be represented as U_{njt}. Utility is divisible into deterministic (V_{njt}) and stochastic (ε_{njt}) components, which respectively account for observable (x_{njt}) and unobservable characteristics of the alternative or individual that affect utility (Train, 2009). The two components typically enter utility additively yielding Equation 3.1 (Hoyos 2010).

$$U_{njt} = V_{njt} + {}^{\varepsilon_{njt}}/_{\sigma} = \beta_n x_{njt} + {}^{\varepsilon_{njt}}/_{\sigma} \tag{3.1}$$

β_n is a vector of individual-specific preference parameters corresponding to the attributes of the good or service (x_{njt}), while σ is a scale parameter that is inversely related to the variance of ε_{njt} (Louviere et al. 2000). Preference parameters may vary across individuals and those that do are assumed to be randomly distributed in the population with continuous density (Train, 2009). To estimate the population parameters for the moments that describe the distribution, β_n is split into components reflecting mean population tastes (β) and individual-specific deviations from this mean (η_n) such that $\beta_n = \beta + \eta_n$ (Revelt and Train 1998). The error term (ε_{njt}) is assumed to be independently and identically distributed (IID) following an extreme value distribution.

This conceptualization of utility conforms to the probabilistic model of choice (Train, 2009). The unconditional probability is the integral of the product of standard logits over each potential value of β_n weighted by the density function $f(\beta_n|\beta, \eta_n)$.[34]

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[33] We removed observations due to missing choice experiment data, serial non-participation, protest responses, responses from non-targeted postal codes, and those owning less than 5 acres of land.

$$\Pr_{njt} = \int \frac{e^{\sigma \beta_n' x_{njt}}}{\sum_j e^{\sigma \beta_n' x_{njt}}} f(\beta_n | \beta, \eta_n) \, d\beta_n \tag{3.2}$$

Since this integral does not have a closed form, approximating the probability requires maximum simulated likelihood estimation (Train, 2009).

A distribution must be assumed for the random parameters (Train, 2009). The log-normal is often used when the preference parameter is expected to have the same sign for all members of the population. Log-normal distributions are often assumed for the payment parameter, though this can result in extremely large welfare estimates with unknown distributional properties (Thiene and Scarpa 2009). A common solution leading to more conservative estimates is to treat the payment parameter as non-random, however this forces the sample to have homogeneous preferences for the payment attribute.

An alternative is to specify models in WTA space (Train & Weeks, 2005; Scarpa, Thiene, & Train, 2008). Such models yield marginal WTA estimates directly as parameters, which circumvents unrealistically large welfare estimates with the added benefits of efficiency and known distributional properties (Thiene and Scarpa 2009). Following Train & Weeks (2005), we separate payment (p) from non-payment (x) attributes to explain the model in WTA space. The scale parameter also varies randomly over individuals.

$$U_{njt} = \alpha_n p_{njt} + \beta_n' x_{njt} + {}^{\varepsilon_{njt}}/_{\sigma_n} \tag{3.3}$$

As with β_n, the payment preference parameter α_n varies randomly across individuals. The error term is still IID following an extreme value distribution but now has variance $(1/\sigma_n^2)(\pi^2/6)$. Multiplying the utility function in Equation 3.3 by σ_n results in a specification that is behaviourally unchanged and still in preference space (Train & Weeks, 2005).

$$U_{njt} = \lambda_n p_{njt} + c_n' x_{njt} + \varepsilon_{njt} \tag{3.4}$$

[34] The scale parameter is confounded with the preference parameters. It cannot be estimated with a single dataset and is often assumed to equal one.

where $\lambda_n = \sigma_n \alpha_n$ and $c_n^{'} = \sigma_n \beta_n^{'}$, while ε_{njt} is IID extreme value with an error variance of $\pi^2/6$. The WTA space model is derived by substituting $\omega_n = c_n/\lambda_n = \beta_n/\alpha_n$ into the utility function in Equation 3.4 and rearranging (Train & Weeks, 2005).

$$U_{njt} = \lambda_n\left(p_{njt} + \omega_n^{'} x_{njt}\right) + \varepsilon_{njt} = \sigma_n \alpha_n \left(p_{njt} + \frac{\beta_n}{\alpha_n} x_{njt}\right) + \varepsilon_{njt} \tag{3.5}$$

The resulting WTA space model is behaviourally equivalent to the scaled model in preference space. As Equation 3.5 makes clear, the WTA parameters (ω_n) are free of the scale parameter though it is confounded with the payment parameter (λ_n).

It is convenient to use a generalized multinomial logit (GMNL) model to estimate parameters in WTP or WTA space (Greene & Hensher, 2010). The GMNL model was originally developed by Fiebig, Keane, Louviere, & Wasi (2010) to account for heterogeneity in scale in addition to preferences. The GMNL model represents the vector of attribute parameters for individual *n* (β_n) as Equation 3.6.

$$\beta_n = \sigma_n \beta + \left[\gamma + \sigma_n\left(1\text{-}\gamma\right)\right]\eta_n \tag{3.6}$$

where β, η_n, and σ_n are as previously defined, while γ is a parameter that controls how η_n varies with scale. The individual specific scale parameter, σ_n, is assumed to be distributed log-normally with mean $\overline{\sigma}$ and standard deviation τ. In conjunction with $\varepsilon_0 \sim N(0,1)$, the standard deviation parameter (τ) captures unobserved scale heterogeneity. Observed scale heterogeneity is captured by making σ_n a function of the characteristics of individual *n* or choice occasion *t* (z_{nt}) with corresponding parameter θ.

$$\sigma_n = \exp\left[\overline{\sigma} + \theta^{'} z_{nt} + \tau \varepsilon_0\right] \tag{3.7}$$

Since β, $\overline{\sigma}$, and τ cannot be separately identified the standard approach is to set $\overline{\sigma}$ = -$\tau^2/2$ so that $E[\sigma_n] = 1$ and then estimate β and τ. As Greene & Hensher (2010) illustrate, the WTA space model is obtained by setting γ to 0 and normalizing the price parameter to 1.

$$\beta_n = \sigma_n \beta + \sigma_n \eta_n = \sigma_n\left((\alpha + \beta) + \eta_n\right) = \sigma_n \alpha\left(1 + \left(\frac{1}{\alpha}\right)(\beta + \eta_n)\right) = \sigma_n \alpha\left(1 + \frac{\beta + \eta_n}{\alpha}\right) \tag{3.8}$$

β_n is incorporated into the logit formulation of the probabilistic model which is estimated via maximum simulated likelihood.

We used Gu et al.'s (2013) ‘gmnl’ command in Stata 12.1 to model the data in WTA space following Hole's (2011) instructions for implementing this model. We treated all parameters as random with non-payment and payment parameters normally and log-normally distributed, respectively. In addition, we estimated the models with a full set of correlation coefficients for the random parameters so that the model accounts for taste and scale parameter heterogeneity (Hess and Train 2017). We used 2000 draws for the maximum simulated likelihood estimation. To incorporate respondent uncertainty, we weighted the choices by respondent certainty on a 10 point scale (Beck et al. 2013). Finally, we chose not to interact socio-economic variables with the attributes to simplify modeling for our main analysis. Using this specification allowed us to explore for the global log-likelihood maximum in a more reasonable amount of time. To do so, we estimated each model ten times using different random starting values — those models yielding the lowest log-likelihood were selected for use in the validity and reliability assessment. Though interactions account for observed heterogeneity, for benefit transfer they can be used to adjust for site differences. However, our samples share reasonably similar characteristics and such adjustments can increase generalization error in this situation (Johnston and Duke 2010).

Nonetheless, we did conduct a sensitivity analysis by modeling a specification that includes demographic interactions with the ASC term (gender, age, education, employment, and income). The goal of this analysis was to examine whether including such interactions altered the validity and reliability of our transfers. Due to missing data on the demographic variables we ran the models with no interactions again for the sensitivity analysis so that identical data is used for the two specifications. We only ran the models once using starting values for the non-interacted parameters from the models estimated for the main analysis (starting values of 0 were used for the parameters representing an interaction). As with the main analysis, we did not adjust the WTA and CS values for site differences using these interactions and instead used the mean values of each demographic variable.

3.2.3. Deriving WTA and CS from the Model in WTA Space

We used the procedures outlined by Czajkowski et al. (2015) and Hu, Veeman, & Adamowicz (2005), originally developed for RPL models, to derive distributions of marginal WTA and CS. The method involves two sequential rounds of simulation: 1) a 'parameter simulation' to account for the sampling distribution of the model parameters; and 2) a 'coefficient simulation' for the random parameters to incorporate variation introduced by heterogeneous preferences. For the parameter simulation, we took $R = 4000$ draws from a multivariate normal distribution. The first and second moments of this distribution, respectively, correspond to the model's parameter vector and variance-covariance matrix. Values of the mean parameters and elements of the lower-triangular of the Cholesky matrix (L) are generated by each draw and over all R draws define the asymptotically normal empirical density of each parameter. For each draw, we then used the elements of L to generate a variance-covariance matrix (Σ) for the random parameters ($\Sigma = LL'$). For the coefficient simulation, we took $S = 4000$ draws from a normal distribution characterized by the mean parameter values and variance-covariance matrix generated from each of the R draws (yielding R vectors of size S).

The elements of the resulting vectors are marginal WTA values and are an input into calculating CS. We calculated CS for each of the $r = 1, \ldots, 4000$ vectors using Equation 3.9.[35]

$$CS_s = -\left(\beta_s x_j^0 - \beta_s x_j^1\right) \; \forall \; s = 1, \ldots, 4000 \qquad (3.9)$$

β_s represents the s^{th} element of the parameter vector, while x_j^1 and x_j^0 are attributes of the alternative and baseline specifications, respectively.

We calculated point estimates over two stages via the 'mean of mean' approach (Hu et al., 2005; Johnston & Duke, 2008). First we calculated the mean of the S marginal WTA or CS estimates for each of the R draws (yielding one vector of size R). Then we took the mean of the resulting R values, yielding the point estimate of marginal WTA or CS. The vector of size R obtained after the first stage is an input into convergent validity testing (Johnston and Duke 2008).

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[35] The payment parameter appearing in the denominator of Hanemann's (1984) equation for calculating CS is unnecessary since the WTA space model's parameters are monetary values.

3.2.4. Transfer Reliability and Validity

We assessed transfer validity by testing the similarity of functions and values resulting from the different case studies. Transfer reliability was assessed by quantifying transfer error (Johnston & Rosenberger, 2010; Boyle et al., 2010).

Testing for Differences in Functions

Evaluating the transferability of functions is critical to any assessment of transfer validity (Boyle et al. 2010). Doing so involves testing whether the vector of parameters (β) comprising the study site's (SS) function are the same as the vector from the policy site (PS). The null hypothesis is that the two vectors are the same and the alternative hypothesis is that they differ (Colombo et al. 2007).

$$\mathrm{H_0}: \beta_{\mathrm{SS}} = \beta_{\mathrm{PS}} \tag{3.10a}$$

$$\mathrm{H_1}: \beta_{\mathrm{SS}} \neq \beta_{\mathrm{PS}} \tag{3.10b}$$

Such tests are complicated by the scale parameter since it is confounded with the preference parameters and may differ across sites (i.e., $\sigma_{\mathrm{SS}} \neq \sigma_{\mathrm{PS}}$). To address this problem, we used the test developed by Swait & Louviere (1993) which uses likelihood ratio tests to compare the model (β) and scale parameters (σ) across sites. Their test involves pooling the data from the different sites and then estimating a model that includes a relative scale parameter ($\sigma_{\mathrm{SS}}/\sigma_{\mathrm{PS}}$) and a model that does not include this parameter.[36] To test the β parameters the pooled model with the relative scale parameter is compared with the two independent models and to test the σ parameter the pooled models are compared.

[36] Swait & Louviere (1993) use a grid search with trial values of the relative scale parameter in repeated model runs. However, we accounted for differences in the scale parameter directly by including a variable representing the data set (as part of z_{nt}) in the pooled GMNL model (Hensher 2012; Kragt 2013). To test model parameters (β), the first pooled model was run 5 times and the model yielding the lowest log-likelihood was used as input into this test. To test the scale parameter (σ), the second pooled model was only run once using starting values from first pooled model.

Testing for Differences in WTA or CS and Calculating Transfer Error

We assessed differences in WTA or CS using two approaches implemented in Stata 12.1.[37] First, we tested whether values are equal across study and policy sites. The null hypothesis is that the estimated values are equal and the alternative hypothesis is that they differ.

$$\mathrm{H_0}: \mathrm{WTA_{SS}} = \mathrm{WTA_{PS}} \tag{3.11a}$$

$$\mathrm{H_1}: \mathrm{WTA_{SS}} \neq \mathrm{WTA_{PS}} \tag{3.11b}$$

We tested these hypotheses using complete combinatorial (CC) tests (Poe et al. 2005). Unlike other tests, the complete combinatorial test does not require normally distributed WTA or CS. The test involves first taking the difference between every element (a and b) of the independent vectors of WTA or CS generated via the simulation approach outlined previously and then computing a p-value as the proportion of negative differences.

$$\left(\mathrm{WTA_{SS}^{a}}\text{-}\mathrm{WTA_{PS}^{b}}\right) \leq 0 \quad \forall\ \mathrm{a} = 1, \dots, \mathrm{R} \text{ and } \mathrm{b} = 1, \dots, \mathrm{R} \tag{3.12}$$

The other approach we used to evaluate differences in WTA or CS was equivalence testing (Schuirmann, 1987; Stegner, Bostrom, & Greenfield, 1996; Muthke & Holm-mueller, 2004; Kristofersson & Navrud, 2005). The premise is that testing if values are equal is not sensible since welfare estimates from different sites are inherently different. Instead values are assumed to differ, but if they fall within a specified tolerance interval they are deemed equivalent. For convergent validity testing this interval represents the maximum tolerance level for the transfer error (±δ %). Following Muthke & Holm-Mueller (2004) and Johnston & Duke (2008), the lower bound of the tolerance interval is $\phi_1 = \text{-}\delta(\overline{\mathrm{WTA}_{\mathrm{PS}}})$ and the upper bound is $\phi_2 = \delta(\overline{\mathrm{WTA}_{\mathrm{PS}}})$. The null and alternative hypotheses are that the values are different and equivalent, respectively.

$$\mathrm{H_0}: \left(\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}}\right) \leq \phi_1 \text{ or } \left(\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}}\right) \geq \phi_2 \tag{3.13a}$$

$$\mathrm{H_1}: \phi_1 < \left(\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}}\right) < \phi_2 \tag{3.13b}$$

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[37] '*WTA*' in the equations denotes either marginal WTA or CS.

We tested these hypotheses using Czajkowski and Ščasný's (2010) variant of Johnston and Duke's (2008) two one sided convolutions (TOSC) test. The TOSC test is an adaptation of the complete combinatorial test and thus does not require normality. This test involves testing two null hypotheses (*H_{0a}* and *H_{0b}*). If both nulls are rejected then welfare estimates at the two sites are considered equivalent at the chosen level of tolerance.

$$\mathrm{H_{0a}}: (\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}}) \leq \phi_1 \text{ or } (\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}})\text{-}\phi_1 \leq 0 \quad (3.14a)$$

$$\mathrm{H_{0b}}: (\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}}) \geq \phi_2 \text{ or } (\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}})\text{-}\phi_2 \geq 0 \quad (3.14b)$$

Implementing the TOSC test requires computing a p-value by taking the difference between every element in the policy and study site WTA or CS vectors generated via the simulation approach outlined previously and then subtracting either ϕ_1 or ϕ_2. The p-value corresponding to *H_{0a}* is the proportion of non-positive differences.

$$(\mathrm{WTA_{SS}^{a}}\text{-}\mathrm{WTA_{PS}^{b}})\text{-}\phi_1 \leq 0 \qquad \forall\ \mathrm{a} = 1, \ldots, 4000 \text{ and } \mathrm{b} = 1, \ldots, 4000 \quad (3.15a)$$

Similarly, the p-value associated with *H_{0b}* is the proportion of non-negative differences.

$$(\mathrm{WTA_{SS}^{a}}\text{-}\mathrm{WTA_{PS}^{b}})\text{-}\phi_2 \geq 0 \qquad \forall\ \mathrm{a} = 1, \ldots, 4000 \text{ and } \mathrm{b} = 1, \ldots, 4000 \quad (3.15b)$$

Czajkowski and Ščasný's (2010) modification of the TOSC test involves calculating the tolerance level (δ) at which both hypotheses are rejected given a certain level of statistical significance using a grid search. Their variant trades the selection of a tolerance level, for which there is no standard when evaluating benefit transfer, for the more familiar choice of a significance level. Note that equivalence tests depend on the transfer's direction since the tolerance intervals are a function of WTA at the policy site.

As suggested by Kaul et al. (2013), we used two different equations to calculate transfer errors. Traditionally, transfer errors have been calculated as a percent via Equation 3.16 (Colombo et al. 2007).

$$\text{Directional Error } (\%) = \left|\frac{\mathrm{WTA_{SS}}\text{-}\mathrm{WTA_{PS}}}{\mathrm{WTP_{PS}}}\right| \quad (3.16)$$

These errors are 'directional' since their magnitude depends on which site is treated as the policy site as this changes the denominator. Chattopadhyay (2003) introduced 'non-directional' errors that are made independent of the transfer's direction by treating the denominator as the average of the values from the two sites (Equation 3.17).

$$\text{Chattopadhyay Error (\%)} = \left|\frac{\text{WTA}_{\text{SS}}\text{-}\text{WTA}_{\text{PS}}}{(\text{WTA}_{\text{SS}}+\text{WTA}_{\text{PS}})/2}\right| \tag{3.17}$$

3.3. Results

3.3.1. Comparison of Respondent Characteristics

A key requirement for valid and reliable benefit transfer is the similarity of populations at the study and policy sites (Johnston and Rosenberger 2010). To establish the degree of similarity of our samples we compared them in terms of their demographic characteristics and the features of the land they own. Our comparison of socio-demographics among the two survey samples indicates significant differences in age and education (Table 3.3). Respondents from the Upper Thames watershed are generally older and more educated than respondents from the Grand watershed. Similarly, there were few differences in land characteristics between the two watersheds (Table 3.4). The Grand and Upper Thames samples only differ significantly in terms of the proportion of respondents reporting meadows and wetlands on their land. A higher proportion of respondents from the Grand watershed report having meadows and wetlands than those from the Upper Thames watershed. Though certain characteristics differ significantly across samples, they are still fairly similar, and the differences observed are similar to those of previous benefit transfer assessments (e.g., Oh 2010; Johnston and Duke 2010; Martin-Ortega et al. 2012; Brouwer et al. 2016). In addition, our samples are reasonably similar to each watershed's population of farm operators in terms of gender, age, and income. However, a much higher proportion of each of our samples holds a post-secondary education relative to the population of farm operators.

Table 3.3: Comparing Respondent Demographic Characteristics Across Watersheds

Respondent Characteristics[a]	Data Type[b]	Watershed		Test Results	Farm Operators[c]	
		Grand	U. Thames		Grand	U. Thames
Gender (%)						
Male	Binary	78.4	77.8		70.3	71.7
Female		21.6	22.2		29.7	28.3
n		529	360			
Age (Adults) (%)						
Under 25	Ordinal	1.0	0.3	***		
25 to 44		26.0	14. 7			
45 to 64		49.5	54.9			
65 or older		23.5	30.1			
Mean (years)	Continuous	54.0	57.3	***	52.5	52.2
n		519	355			
Highest level of education (%)						
Less than high school	Ordinal	26.5	7.8	***		
High school		29. 0	31.9			
Post-secondary		44.5	60.8		14.4	
n		524	357			
Employment status (%)						
Not in labour force	Categorical	20.9	18.2			
Unemployed		1.3	0.3			
Employed		77.8	81.5			
n		522	357			
Household Income (%)						
Less than $10,000	Ordinal	1.4	0.3			
$10,000 to $29,999		5.9	5.8			
$30,000 to $49,999		17.7	15.8		28.8	
$50,000 to $74,999		22.6	20.1		20.6	
$75,000 to $99,999		21.2	26.1		16.9	
$100,000 and more		31.2	31.9		33.7	
n		491	329			

*** indicates that the characteristic differs at the 99% level of significance

[a] Since we deleted missing values from this data the sample sizes do not always align with those from the choice model and are noted for each characteristic in the table.

[b] Testing was completed using Pearson's chi-square tests for binary or categorical data (Fisher's exact test was used if a cell count less than 5) and Wilcoxon / Mann-Whitney tests for ordinal and continuous data.

[c] Data on the gender and age of the population of farm operators is from the 2011 Census of Agriculture (Statistics Canada 2012) for census consolidated subdivisions intersecting with each watershed. Education and household income are at the provincial level. Education is only available as the proportion with a post-secondary education (or not) and income is only available for the following categories: Less than $50,000; $50,000 to $74,999; $75,000 to $99,999; $100,000 and more. Employment status is not available, though all farm operators are likely employed.

Table 3.4: Comparing Respondent Land Characteristics Across Watersheds

Land Characteristic[a]	Data Type[b]	Watershed		Test Results
		Grand	U. Thames	
Land Cover (%)				
Has forests	Binary	63.3	63.3	
Has meadows	Binary	28.4	18.0	***
Has wetlands	Binary	62.9	42.3	***
Has crop, pasture, or orchard (i.e., agricultural land cover)	Binary	91.9	93.6	
Land Use (%)				
Primary land use is agriculture or forestry	Categorical	81.1	85.8	
Primary land use is residential		17.0	13.1	
Primary land use is other		1.9	1.1	
Generated income from land in past 5 years (%)	Binary	87.9	90.6	
Area of Land Holdings				
Mean (acres)	Continuous	146.3	168.4	
Farm or forest producer[c] (%)	Binary	79.7	83.4	

*** indicates that the characteristic differs at the 99% level of significance

[a] Sample sizes for each characteristic are generally 531 in the Grand and 362 in the Upper Thames. Exceptions include: 'Has Wetlands' is 528 in the Grand and 359 in the Upper Thames; 'Land Use' is 523 in the Grand and 360 in the Upper Thames; and 'Farm or forest producer' is 507 in the Grand and 344 in the Upper Thames.

[b] Testing was completed using Pearson's chi-square tests for binary or categorical data (Fisher's exact test was used if a cell count less than 5) and Wilcoxon / Mann-Whitney tests for continuous data.

3.3.2. Modelling Results

The pseudo-R^2 measures indicate that the models estimated for the Grand and Upper Thames watersheds fit the data well (Table 3.5). In terms of the mean parameters, the ASC coefficients are positive and insignificant for both models. The parameters estimated for the area conserved indicate that respondents in the Grand and Upper Thames watersheds prefer to conserve smaller areas of their land. Respondents in both watersheds prefer if the area conserved is marginal rather than productive and they favour if this land is converted to trees, followed by meadow, and then wetlands. The public recognition coefficients indicate that respondents in the Grand watershed dislike receiving recognition for their conservation efforts, while the mean parameter estimated for the Upper Thames is insignificant.

Table 3.5: Models in Willingness to Accept Space

Variables	Grand	Upper Thames
Mean[a]		
ASC	0.8732	0.4840
	(0.7511)	(0.7609)
Acres	-0.1863*	-0.3350***
	(0.1040)	(0.0993)
Land Type (productive)	-2.4562***	-2.0577***
	(0.2655)	(0.2225)
Activity: Wetland	-1.0906***	-1.1647***
	(0.2631)	(0.2391)
Activity: Trees	1.2675***	1.1204***
	(0.2551)	(0.2060)
Recognition (yes)	-0.9100***	0.0584
	(0.3212)	(0.2672)
Elements of the Lower Triangular Cholesky Matrix		
ASC × ASC	9.9755***	8.2197***
	(1.1793)	(0.9658)
Acres × ASC	-0.0110	-0.1386
	(0.1795)	(0.1532)
Land Type × ASC	0.3196	0.0549
	(0.3653)	(0.3118)
Wetland × ASC	0.1815	0.1457
	(0.3829)	(0.3584)
Trees × ASC	-0.0781	0.1342
	(0.3809)	(0.3296)
Recognition × ASC	0.6588	-0.0185
	(0.4650)	(0.4198)
Acres × Acres	-0.9235***	-0.6647***
	(0.1721)	(0.1513)
Land Type × Acres	-0.8498*	-0.1837
	(0.5065)	(0.3701)
Wetland × Acres	-0.0308	-0.8245*
	(0.5201)	(0.4459)
Trees × Acres	0.2704	0.5306
	(0.4764)	(0.3445)
Recognition × Acres	0.4236	0.1868
	(0.5610)	(0.5240)
Land Type × Land Type	-2.6687***	1.7672***
	(0.3165)	(0.2495)
Wetland × Land Type	0.7983**	-0.4238
	(0.3485)	(0.3708)
Trees × Land Type	-0.1004	-0.1892
	(0.3528)	(0.3115)
Recognition × Land Type	0.6618	-0.0292
	(0.4591)	(0.4127)
Wetland × Wetland	-2.5907***	1.7040***
	(0.3828)	(0.3249)

Variables	Grand	Upper Thames
Trees × Wetland	1.6115***	-0.5810*
	(0.3587)	(0.3374)
Recognition × Wetland	0.4688	1.0332**
	(0.5234)	(0.4168)
Trees × Trees	2.1302***	1.1877***
	(0.2768)	(0.2384)
Recognition × Trees	-0.2523	-0.1550
	(0.4506)	(0.4865)
Recognition × Recognition	-2.4247***	1.1270**
	(0.4383)	(0.5714)
Scale		
Constant (θ)	-0.6327***	-0.2085
	(0.1886)	(0.2576)
Tau (τ)	0.3833	0.6463***
	(0.2567)	(0.2511)
Model Statistics		
Observations	9492	6423
Log-likelihood	-1760.97	-1154.23
Pseudo R^2	0.29	0.31

[a] Coefficients represent the negative of WTA values scaled by 100 since the payment attribute was divided by 100 to aid model convergence. Standard errors appear in brackets below the corresponding coefficient.

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

We used the elements of the lower triangular of the Cholesky matrix to estimate each model's variance-covariance matrix as well as the standard deviation parameters via the Delta method (see Appendix B2). The standard deviation parameters estimated from the models are all significant suggesting that preferences for each attribute are heterogeneous in both watersheds. Further, certain off diagonal elements of the variance-covariance matrix are significant, suggesting that preferences for these attributes are related (the particular elements differ by watershed). For the Grand watershed, preferences for land type are negatively related to the conversion activity being wetland, while preferences for the conversion activity being wetland are negatively related to the conversion activity being trees. For the Upper Thames, preferences for the conversion activity being wetland are negatively related to this activity being trees. Conversely, preferences for the conversion activity being wetland are positively related to the number of acres conserved and public recognition. The constant for observed scale heterogeneity, θ, is only significant in the case of the Grand watershed. The τ parameter, which represents unobserved scale heterogeneity, is only significant for the Upper Thames watershed model.

On the surface the models estimated for the Grand and Upper Thames are similar and our Swait and Louviere (1993) likelihood ratio test bears this out (see Appendix B3). The first pooled model yields a log-likelihood of -2929.00 and the likelihood ratio test fails to reject the null hypothesis of equal model parameters $\left(\mathrm{X}^2_{(29)} = 27.59 \text{ and p-value} = 0.54\right)$. The pooled model for the second likelihood ratio test yields a log-likelihood of -2929.16 and thus we also fail to reject the null hypothesis of equal scale parameters $\left(\mathrm{X}^2_{(1)} = 0.32 \text{ and p-value} = 0.57\right)$ which aligns with the insignificance of the parameter accounting for the differing scales in the first pooled model. Thus the two models do not differ significantly from one another.

3.3.3. Willingness to Accept, Transfer Errors, and Testing

Marginal Willingness to Accept

Marginal WTA estimates reflect the model parameters since they were generated from coefficients in WTA space. Note that for the land productivity and conversion activity attributes we included estimates derived directly from the effects coded coefficients as well as those representing a change.[38] Annual per acre marginal WTA point estimates for the Grand watershed range from -$239.27 for setting aside marginal land (effects) to $478.53 for moving from marginal to productive land. Similarly, these estimates for the Upper Thames watershed range from -$203.50 for setting aside marginal land (effects) to $407.00 for changing from marginal to productive land (Table 3.6). In general, the marginal values estimated for the two watersheds are fairly similar though notably different estimates were observed in the case of the area converted, conversion activity being meadow, and receiving public recognition.

[38] Note that the values estimated for the effects coded variables, as well as the ASC term, are not strictly marginal since they do not reflect a change in attribute levels. However, we have retained these values for the transfer validity and reliability assessment since they are used to calculate compensating surplus.

Table 3.6: Marginal WTA and Errors for Transfers Between Two Watersheds in Southern Ontario

Attribute	Marginal WTA (2013 CAD)[a]		Errors (%)				Testing			
	Grand	Upper Thames	PS: Grand	PS: Thames	Mean Directional	Chatto-padhyay	CC	Tolerance Levels (%)[b] PS: Grand	PS: Thames	Mean Tolerance (%)
ASC	-113.74 (-262.51 to 32.45)	-70.48 (-220.57 to 76.75)	38	61	50	47	0.34	194	312	253
Acres	14.30 (-5.86 to 34.28)	29.77 (10.62 to 48.58)	108	52	80	70	0.14	273	131	202
Land Type										
Productive (effects)	239.27 (184.97 to 291.22)	203.50 (157.7 to 246.71)	15	18	16	16	0.15	39	46	43
Marginal (effects)	-239.27 (-291.22 to -184.97)	-203.50 (-246.71 to -157.70)	15	18	16	16	0.15	39	46	43
Marginal to productive	478.53 (369.93 to 582.44)	407.00 (315.39 to 493.41)	15	18	16	16	0.15	39	46	43
Activity										
Wetland (effects)	111.53 (59.30 to 165.17)	120.65 (73.28 to 169.17)	8	8	8	8	0.40	62	58	60
Trees (effects)	-121.14 (-170.05 to -70.26)	-109.67 (-149.64 to -69.21)	9	10	10	10	0.36	55	60	58
Meadow (effects)	9.62 (-35.81 to 56.37)	-10.98 (-52.94 to 31.63)	214	188	201	3020	0.26	766	671	719
Meadow to trees	-130.76 (-211.21 to -49.27)	-98.69 (-168.22 to -31.28)	25	32	29	28	0.28	93	123	108

Attribute	Marginal WTA (2013 CAD)[a]		Errors (%)				Testing			
	Grand	Upper Thames	PS: Grand	PS: Thames	Mean Directional	Chatto-padhyay	CC	Tolerance Levels (%)[b] PS: Grand	Tolerance Levels (%)[b] PS: Thames	Mean Tolerance (%)
Meadow to wetland	101.91 (16.21 to 189.47)	131.64 (51.93 to 215.15)	29	23	26	25	0.31	127	98	113
Trees to wetland	232.67 (140.88 to 325.40)	230.33 (152.29 to 309.90)	1	1	1	1	0.49	45	46	46
Recognition (yes vs. no)	91.28 (28.47 to 155.20)	-6.52 (-58.68 to 46.46)	107	1500	804	231	0.01***	183	2560	1372
Mean (Median) Error or Tolerance (%)										
Includes effects coded estimates			64 (27)	232 (35)	148 (28)	427 (32)		201 (123)	486 (96)	343 (97)
Includes change coded estimates			46 (29)	241 (32)	144 (31)	60 (28)		136 (127)	474 (123)	305 (125)

[a] 95% confidence intervals, estimated via the Krinsky-Robb method with 4000 draws, appear in brackets below each implicit price

[b] The tolerance levels represent the threshold at which the pairs of estimates are deemed equivalent at the 95% level of significance.

*** indicates that the CC test finds the pair of implicit prices to be *different* at the 99% level of significance

Depending on the site treatment and attribute, directional transfer errors range from 8% to 1500%. In most cases, the directional transfer errors do not differ substantially by treatment of the policy site. However, policy site treatment clearly matters for transfers of marginal WTA for public recognition. For transfers of this value from the Upper Thames to the Grand the directional error is 204%, while the reverse direction yields an error of 1500%. While the magnitude of the errors sometimes depends on the transfer's direction, the mean of the directional errors reveals that the lowest errors are observed for changing the conversion activity from trees to wetland, conversion activity being wetland (effects), followed by conversion activity being trees (effects), land type (marginal/productive (effects) or change from marginal to productive), changing the conversion activity from meadow to wetland, changing the conversion activity from meadow to trees, ASC, area converted, conversion activity being meadow (effects), and public recognition.

The non-directional errors generally confirm the results obtained for the directional errors. However, the non-directional errors suggest that the conversion activity being meadow yields the highest error rather than public recognition. In general, the Chattopadhyay errors fall between the directional errors and are similar to the mean of the directional errors. However, certain errors are much larger than their directional counterparts and this occurs when the marginal values being compared are of similar magnitude but opposing signs (e.g., conversion activity being meadow). These conditions can lead to exploding non-directional errors (see Appendix B4). There is also a disparity between the mean of the directional errors and the non-directional errors when the values being compared have opposing signs, but are not of similar magnitude (e.g., public recognition).

The complete combinatorial (CC) tests indicate that only the marginal WTA estimates for public recognition significantly differ for transfers between the two watersheds. All of the estimated tolerance levels are larger than the corresponding transfer errors. As with the transfer errors they vary by the treatment of the policy site. Depending on the site treatment and attribute, tolerance levels range from 39% to 2560% for transfers between the Grand and Upper Thames watersheds. The mean of the tolerance levels across the two transfers reveals that the lowest and highest tolerance levels are generally observed for the land type and public recognition attributes, respectively. Note that transfers with the lowest (highest) errors do not necessarily generate the lowest (highest) tolerance levels. In addition, even if the complete combinatorial test deems a pair of estimates equal it does not guarantee that the corresponding tolerance level will be lower than a pair deemed unequal by this test.

Contrasting the transfer assessment results for the effects coded estimates with the associated change coded estimates reveals that the effects and change coded estimates derived for the land type attribute yield identical errors, tolerance levels, and CC p-values. This finding is not surprising since the land type attribute only has two levels, ensuring that the two types of estimates are constant multiples of each other. For the conversion activity attribute, the results are not identical across effects coded and change coded estimates. On average, the effects coded estimates yield larger errors and tolerance than their change coded counterparts (due to the larger errors and tolerance levels observed for the meadow effects coded estimates). However, the outcomes of the CC tests are the same.

Compensating Surplus

Plotting the compensating surplus point estimates for all 36 conservation program specifications, with each specification representing a certain combination of the non-payment attributes' levels, reveals that mean compensating surplus estimates from the two watersheds are clearly similar (Figure 3.2). Depending on the specification, mean compensating surplus estimates range from -$459.85 to $399.82 for the Grand River watershed and -$360.40 to $402.52 for the Upper Thames River watershed. The CS estimates are always negative and positive when the land type being conserved is marginal and productive, respectively.

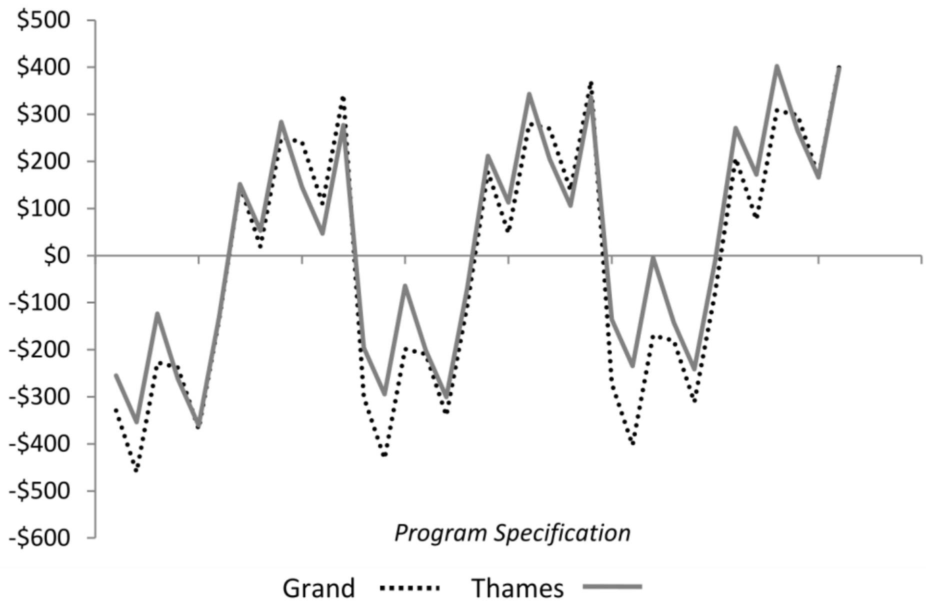

Figure 3.2: Compensating Surplus Estimates for All Possible Program Specifications by Watershed

The observed errors and tolerance levels for transfers of CS vary by study or policy site treatment and program specification (Table 3.7 and Figure 3.3). Directional errors range from 1% to 3691%, non-directional errors from 1% to 190%, and tolerance levels from 47% to 7914%. The average of the directional errors for transfers from the Grand to the Upper Thames is larger than for transfers to the Upper Thames. A similar finding is observed for the tolerance levels. In addition, the non-directional errors are within the range of their directional counterparts. Furthermore, the complete combinatorial tests indicate that only two pairs of CS estimates are significantly different and only at the 10% significance level. Finally, box plots make apparent that the distributions of compensating surplus transfer errors and tolerance levels are often right-skewed (Figure 3.3). In addition, these plots indicate that the distribution of errors and tolerance levels are more right-skewed for transfers to the Upper Thames than in the other direction.

Table 3.7: Summary of Errors, Tolerance Levels, and Complete Combinatorial Tests for Transfers of Compensating Surplus Between Two Southern Ontario Watersheds

Transfer	Transfer Errors (%)				Tolerance Levels (%)				CC (Different Pairs)
	Mean	Median	Low	High	Mean	Median	Low	High	
Directional									
Grand to U. Thames	157	29	1	3691	433	116	48	7914	N/A
U. Thames to Grand	38	23	1	184	161	102	47	1141	
Non-Directional									
Grand and U. Thames	41	26	1	190	N/A				2*, 0**, 0***

*, **, and *** indicate the number of pairs of compensating surplus estimates the CC test finds *different* at the 90%, 95%, and 99% levels of significance, respectively

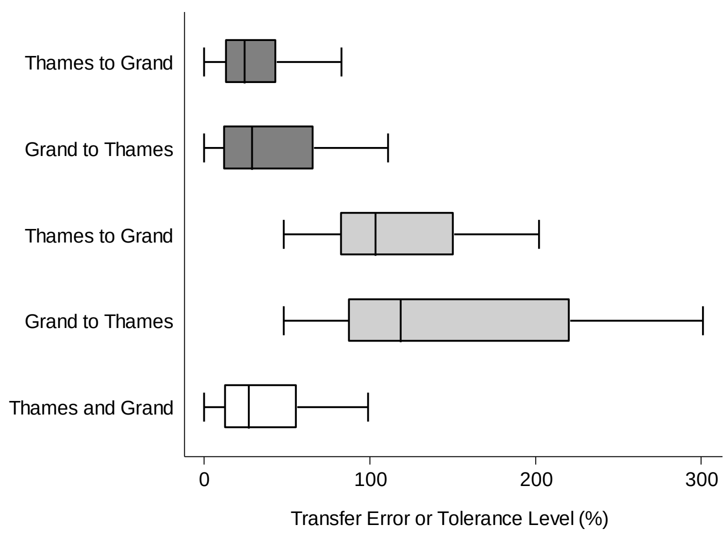

Figure 3.3: Box Plots of Transfer Errors and Tolerance Levels
Note: Outlier points are not plotted. Directional error boxes are dark grey, tolerance level boxes are light grey, and Chattopadhyay error boxes are white.

3.3.4. Sensitivity Analysis

The stages of our sensitivity analysis mirror those of the main analysis (see Appendix B5). We first compared the sample characteristics and the two models without interactions to establish the degree of similarity between the main and sensitivity analyses. Our findings suggest that the samples used for the sensitivity and main analyses share very similar respondent characteristics. Likewise, the two models without demographic interactions are fairly similar as are the mean WTA and CS values derived from these two specifications and the results of the validity and reliability assessments for transfers of these values.

In terms of the model with demographic interactions, interactions with age are significant in the case of the Upper Thames, while those with gender, age, and education are significant for the Grand. These models fit the data better than the models without interactions, though they are less parsimonious according to certain information criteria. The interactions do not substantially change the reliability of our transfers. Aside from a few outliers, the errors from the two model specifications were fairly similar though the model with interactions did yield slightly higher errors overall. In terms of validity, the outcomes of the Swait and Louviere (1993) likelihood ratio tests assessing model similarity were identical as were the outcomes of the complete combinatorial tests assessing the similarity of WTA or CS estimates. However, a marked difference in the validity of transfers based on the two models emerges when looking at the estimated tolerance levels. While these results are generally similar for most transfers of marginal WTA, tolerance levels are notably higher for transfers of marginal WTA estimated for the ASC term derived from the model with demographic interactions. Additionally, the tolerance levels estimated for transfers of CS are much higher for transfers based on this model relative to the model without interactions. This outcome reflects the higher variation in WTA for the ASC term observed to result from the model with demographic interactions. The highly variable marginal WTA for the ASC term also yields inefficient CS estimates (standard deviations are much larger for CS values derived from the model with interactions compared to the model without interactions). This finding persists even after dropping insignificant interaction variables from the models.

3.4. Discussion and Conclusions

Overall, our results are similar to those found in the convergent validity literature summarized by Rosenberger (2015) — given the evidence we reject the null hypothesis that the validity and reliability of transfers of WTA differs from the validity and reliability of transfers of WTP (the results of our sensitivity analysis do not change this conclusion). For transfers of marginal WTA, our directional errors range from 8% to 1500% with a mean of 148% and median of 28%, while directional errors for transfers of compensating surplus range from 1% to 3691% with a mean of 97% and median of 25%. Non-directional errors for transfers of marginal WTA range from 8% to 3020% with a mean of 427% and median of 32%. For transfers of compensating surplus these errors range from 1% to 190% with a mean of 41% and median of 26%.

Our likelihood ratio test of model coefficients fails to reject the hypothesis of parameter equality. In terms of values, 1 of 12 tests find marginal WTA estimates differ and 2 of 36 tests find that CS estimates differ (significance level of at least 10%). The tolerance levels estimated in our study for marginal WTA range from 39% to 2560% with a mean of 343% and median of 97%, and range from 47% to 7914% with a mean of 297% and median of 111% for compensating surplus. Our mean tolerance level estimates are generally higher than those in Czajkowski & Ščasný (2010). Additionally, if a pair of estimates is deemed equal using the complete combinatorial test it does not mean that the associated tolerance level will be lower than the level corresponding to a pair deemed unequal by this test. This outcome may result if the estimates being tested have a high variance (Kristofersson & Navrud, 2005; Johnston & Duke, 2008). In the case of equivalence testing, if estimates are inefficient they are more likely to be deemed unequal leading to higher tolerance levels. However, the complete combinatorial test uses traditional hypotheses and is more likely to find such estimates equal.

The validity and reliability of our transfers of WTA may be similar to prior transfers of WTP for a number of reasons. Importantly, the demographic and land characteristics of our study sites are similar as are the characteristics of the two samples drawn from these sites. As outlined in the introduction, such similarity is an important consideration for benefit transfer. Our results for transfers of WTA may also be similar to those observed for WTP if, as noted in the introduction, the disparity between the two measures is relatively small or constant across our sites. This disparity is likely fairly constant across sites since our case study sites share similar demographic characteristics. Furthermore, the disparity in the measures is likely small for two reasons. First, the vast majority of the respondents to our survey were agricultural or forest product producers and they may not experience consequential loss aversion since they are experienced economic actors. Second, WTP and WTA approximate one-another when these values are elicited for ordinary private goods — the choice experiment essentially asked respondents to lease portions of their land for wetlands conservation, which is effectively a private good from the perspective of landowners. Finally, Rosenberger (2015) notes that the higher directional errors observed in their review could result from experimental studies comparing estimates that would rarely or never be compared in policy analysis.

The findings of our sensitivity analysis reflect in part those of Ostberg et al. (2013), that model specification does not substantially influence transfer performance. Our assessment revealed that transfer reliability and certain aspects of validity are largely the same for transfers based on models with and without demographic interactions with the ASC term. However, tolerance levels estimated for transfers of marginal WTA for the ASC term and CS based on the model with interactions were notably larger than those based on the model without interactions suggesting that values from the former model are less likely to be equivalent than those derived from the latter. Basing the transfers on a model with significant interactions only did not address this issue. This result is driven by variability in these WTA values introduced by the interactions. As discussed earlier, equivalence testing penalizes transfers of inefficient estimates yielding larger tolerance levels.

Our findings can also inform wetlands conservation policy in the Grand and Upper Thames watersheds. On average, participation in wetlands conservation could be increased if associated conservation programs: target smaller marginally productive areas of land; buffer existing wetlands with trees or meadows rather than build new wetlands; do not offer public recognition; and offer higher payments. However, preferences for these attributes are heterogeneous and conservation groups should take this into account when designing wetlands conservation programs in these watersheds. Furthermore, given the results of our transfer assessment these relationships could be used to aid wetlands conservation in other similar regions.

We believe that this research shows that the reliability and validity of transferring WTA is similar to that found for transfers of WTP. Given the growing number of primary valuation studies eliciting WTA, our findings suggest that these WTA values can be used in benefit transfer as part of policy analysis (at least in the context examined in this paper). Furthermore, our sensitivity analysis suggests that transfers of compensating surplus based on choice models that include interactions of demographic characteristics with the alternative specific constant can reduce validity relative to models without such interactions. However, similar to transfers of WTP further research is required to better understand other settings and conditions under which transfers of WTA are more likely to be accurate. An extension of our research would be to implement parallel WTA and WTP valuation case studies at the same sites (valuing the same goods). This would allow an interesting twist on our research, which would be an assessment of the implications of transferring a WTP measure estimated at a study site when the correct measure for the change at the policy site is actually WTA (and vice versa). Benefit-cost analyses often apply the WTP measure when WTA is more appropriate, even when using original research, since WTP is seen by many as a more reasonable measure (Hammitt 2015). Although theoretically inappropriate, as highlighted by Knetsch (2007), and discouraged by the United States Office of Management and Budget (2003) such transfers would be pragmatic and reflect policy analyses when existing values estimated using the correct measure are unavailable for input into benefit transfer.

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Chapter 4.

Assessing the Convergent Validity and Reliability of Transfers of Market Shares Derived from Choice Experiments for Landowner Participation in Wetlands Conservation Programs

A version of this chapter is currently under peer review at Resource and Energy Economics as Trenholm, R., Lantz, V., Knowler, D., and Haider, W. "Comparing the Convergent Validity of Transfers of Choice Probability Market Shares and Welfare Estimates". I led the design of this research and was the lead on the fieldwork. I authored nearly all of the text and conducted all of the data analyses.

Abstract

Market shares derived from choice experiments can inform policy development in several fields. For example, they can be used to predict the proportion of private landowners who may participate in a given conservation program. Similar to non-market values, these predicted participation market shares can be difficult to obtain using original research, but transfers may be possible. However, such transfers have not been assessed using convergent validity tests similar to those used to test benefit transfer. We used standard techniques to assess the validity and reliability of transfers of these market shares. To provide context we compared these results with a parallel assessment of transfers of compensating surplus. Market share and compensating surplus estimates were derived from choice experiments that elicited the preferences of rural landowners in two Canadian watersheds for enrolling their land in wetlands conservation programs. Validity was assessed by testing the similarity of models and estimates, while reliability was assessed by calculating directional and non-directional transfer errors. Structural differences dictate that transfers of market shares should be more reliable and valid than transfers of compensating surplus estimated from the same models and our results bear this out. Our findings hint that transfers of market shares could be appealing for policy analysis when original research is not possible. However, more research is required to determine the threshold levels of validity and reliability at which such transfers are desirable.

Keywords: benefit transfer; convergent validity; willingness to accept; compensating surplus; market share; choice experiment

4.1. Introduction

Benefit transfer is commonly applied in economic analyses such as benefit-cost analysis when the resources required for estimating non-market values using original research are limited. This technique involves transferring economic welfare estimates across space, time, or populations from the location of the existing value, known as the study site (SS), to the site of the current analysis, known as the policy site (PS) (Boyle, Kuminoff, Parmeter, & Pope, 2010). Benefit transfers are subject to a range of errors, notably generalization error which results from differences in study and policy sites (Johnston & Rosenberger, 2010). As such, studies assessing the validity and reliability of the technique have become commonplace (see Kaul, Boyle, Kuminoff, Parmeter, & Pope (2013) or Rosenberger (2015) for a review).[39] These convergent validity studies have traditionally used estimates of willingness to pay (WTP), often estimated from choice experiments, in their assessments (e.g., Brouwer et al., 2016; Colombo, Calatrava-Requena, & Hanley, 2007). An additional output of choice experiments are market or choice shares that indicate the proportion of respondents expected to select a certain specification of a good or service out of a set of alternative specifications (Hensher, Rose, & Greene, 2015). This output can be used in a decision support tool to help predict the share of policy support received by any one of the possible scenarios or states of the world that can be represented from a choice experiment's attributes.

Choice experiments are widely applied worldwide and studies estimating market shares span the literature, including fields such as recreation and tourism, farmer and landowner decision making, transportation, food and beverage, as well as health and medicine (e.g., Arellano et al., 2015; Koemle & Morawetz, 2016; U. Pröbstl-Haider et al., 2016; Rose & Hensher, 2014; Wu et al., 2015). Few studies that have estimated market shares implement similar choice experiments across space, time or populations and those that do are not convergent validity analyses (e.g., Landauer, Pröbstl, & Haider, 2012). Obtaining market shares from original research can be expensive since it involves the same amount of effort required to elicit welfare estimates. Therefore

[39] Several factors influence the validity and reliability of benefit transfers (Kaul et al., 2013). For instance, transferring functions that relate economic values to observable site characteristics is more accurate than transferring adjusted or unadjusted unit values, particularly when sites are different, since functions can account for site characteristics. In addition, using values from multiple studies and geographically similar areas leads to more accurate benefit transfers (site similarity is a key condition for accurate transfers (Boyle et al., 2010)).

transferring market shares is desirable. However, to our knowledge the validity and reliability these transfers has never been explicitly explored in the same sense as benefit transfer.

Transfers of market shares could inform resource and environmental management policy, such as the development or modification of voluntary conservation or agri-environmental programs on private lands (a well-known example of such schemes is the Conservation Reserve Program (United States Department of Agriculture, 2017)). In these cases, transfers could be used to gauge the impact of key program attributes on the proportion of landowners predicted to participate in conservation programs. While informing the modification or development of these programs through original research may be more desirable, we envision a few key benefits of transferring predicted market shares. As previously mentioned, original choice experiment research may not always be possible due to time or budget limitations. However, even if possible such original research is still limited by available resources, perhaps to a single choice experiment survey. In this case, transferring market shares may enable policy makers to access a wider range of information than might otherwise be available.

The validity and reliability of market share transfers should differ from that of transfers of WTP or willingness to accept (WTA) due to differences in how the two types of values are calculated (see Hensher, Rose, & Greene (2015) for an overview of how to calculate these values). Market shares are bounded by 0 and 1, which limits the range of possible transfer errors. For instance, assuming transfers of market shares that are non-zero integers the range of possible percentage transfer errors is 0% to 9900% with mean of 211% and median of 61% (errors are highest when the market shares are 0.01 and 1, respectively, at the policy and study sites; see Appendix C1 for a visual representation of the distribution of potential errors). Economic values such as WTP or WTA are not similarly constrained, meaning that the range of possible transfer errors is larger.

Differences in the study and policy sites, such as the alternatives differing in number or type, could pose a challenge for transfers of market shares not necessarily faced by transfers of WTP or WTA. The policy and study sites may differ such that different alternatives are required to properly represent the goods or services available at each site (e.g., transfers of beach visitation between sites with a different number of beaches or transfers of transportation mode choices between sites with different transportation options). In this case market share transfer may be difficult, or even impossible if there are substantial differences, since choices may be distributed over a wider range of alternatives at one site relative to the other. Transfers would be especially difficult if certain alternatives are not relevant at both sites. However, transfers between substantially different policy and study sites, each with choice sets comprised of a very different number or type of alternatives, is likely not desirable in the first place. Consider that valid and reliable benefit transfers require similar site characteristics, including “the availability of substitutes” (Boyle, Kuminoff, Parmeter, & Pope, 2010). This suggests that choice sets at the study and policy sites should include the same, or at least a very similar, number of alternatives since each alternative represents a substitute. Furthermore, the set of alternatives from the study site should be relevant at the policy site. Transfers of all types need to be carefully thought out and similar site or policy characteristics are important — as with benefit transfer there will be cases where market share transfer will and will not be feasible.

Our study contributes to the literature by reporting on research into the validity and reliability of transfers of market shares derived from choice experiments using convergent validity tests commonly used in benefit transfer validity and reliability testing. To provide context, these results are contrasted with those from an assessment of the validity and reliability of transfers of compensating surplus estimates derived from the same models. Given that market shares are bounded by 0% and 100% by definition, and compensating surplus estimates are unbound, transfers of market shares should be more valid and reliable than transfers of compensating surplus. While such an 'apples to oranges' comparison may seem uninformative given these structural differences, it serves to benchmark the convergent validity of our market share transfers against that of welfare estimates. Our analysis relied on data from case studies in two Canadian watersheds that used choice experiments to elicit the preferences and willingness to accept (WTA) of rural landowners for incentive-based wetlands conservation programs. We focus on the decision of landowners to adopt a particular conservation program relative to maintaining the status quo (i.e., the predicted share of landowners who would enrol versus sticking with the status quo or the financial compensation required for them to move to the conservation program from their status quo [hereafter "market share"]).[40] We review our study's method in the next section, followed by the data, the results, and finally a discussion and conclusion.

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[40] The binary adoption decision is a subset of possible market shares (in the case of multiple alternatives versus the status quo, market shares could be calculated for each alternative and the status quo). However, the decision to adopt the conservation program or not does correspond with the change represented by compensating surplus values (which reflects the compensation required to adopt).

4.2. Method

4.2.1. Econometric Modeling

We analyzed our data using random parameter logit (RPL) models since they improve the accuracy of benefit transfers relative to a conditional logit (Colombo et al., 2007). The analysis is rooted in the random utility model (McFadden, 1974; Train, 2009). The premise of this model is that individuals make choices among alternatives based on relative utility (U). Given the set of alternative specifications of goods or services $\mathrm{j} = 1, \dots, \mathrm{J}$ a rational individual n will choose alternative i over all other alternatives j on choice occasion t if $\mathrm{U_{nit}} > \mathrm{U_{njt}}\ \forall\ \mathrm{i} \neq \mathrm{j}$ all else equal. Utility ($\mathrm{U_{njt}}$) is divisible into a deterministic ($\mathrm{V_{njt}}$) component, which is a function of the alternative's attributes ($\mathrm{x_{njt}}$), and a stochastic error term ($\varepsilon_{\mathrm{njt}}$).

The RPL explicitly incorporates heterogeneous tastes for the attributes by allowing preference parameters (β_{n}) to differ across individuals (known as random parameters). Preferences are assumed to be randomly distributed in the population according to a probability density function (Train, 2009). β_{n} is segmented into a mean component (β), which captures average sample preferences, and a standard deviation component (η_{n}) that accounts for individual-specific deviations from the mean. Utility is thus represented as Equation 4.1.

$$\mathrm{U_{njt}} = \mathrm{V_{njt}} + {}^{\varepsilon_{\mathrm{njt}}}\!/_{\sigma} = \alpha_{\mathrm{njt}} + (\beta + \eta_{\mathrm{n}})\mathrm{x_{njt}} + {}^{\varepsilon_{\mathrm{njt}}}\!/_{\sigma} \tag{4.1}$$

where α is an alternative specific constant (ASC) term and σ is the scale parameter.[41] Due to the error term, the RUM becomes the probability that individual n will choose alternative i over all others j on occasion t such that $\mathrm{Pr_{nit}}\big(\mathrm{V_{nit}} + \varepsilon_{\mathrm{nit}}/\sigma > \mathrm{V_{njt}} + \varepsilon_{\mathrm{njt}}/\sigma\big)\forall\ \mathrm{i} \neq \mathrm{j}$. This expression is reformulated using a logit formulation for the unconditional probability that individual n will choose alternative i over all other alternatives j (Equation 4.2).

[41] The scale parameter is inversely related to the variance of the error term. Given a single dataset σ is typically assumed to equal 1, although it can differ over datasets (Swait & Louviere, 1993).

$$\mathrm{Pr}_{\mathrm{nit}} = \int \frac{e^{\sigma\beta_n x_{\mathrm{nit}}}}{\sum e^{\sigma\beta_n x_{\mathrm{njt}}}} f(\beta_n) d(\beta_n) \tag{4.2}$$

Since the integral is not of closed form, maximum simulated likelihood estimation is required to generate the parameter estimates (Train, 2009). Our RPL models were estimated in Stata 12.1 using the 'mixlogit' command with 2000 Halton draws (Hole, 2007). All parameters were treated as random to allow preference heterogeneity for all choice experiment attributes with non-payment and payment parameters normally and log-normally distributed, respectively. The log-normal payment forces a positive parameter which conforms to theoretical expectations since larger payments should increase landowner utility, though as discussed later this has implications for estimating economic values. We ran models with and without correlated random coefficients and used a likelihood ratio test to select the specification for our transfer assessment.[42] Models with correlated random coefficients yield lower-triangular Cholesky matrix coefficients in addition to mean parameters, while models with independent random coefficients produce standard deviation coefficients. We did not interact any of the choice experiment variables with socio-economic characteristics since the effect of such interactions on transfer validity and reliability is unclear.[43] To combat hypothetical bias we calibrated our data for respondent certainty, a common approach in stated preference research which has been used in previous choice experiment studies (Beck, Rose, & Hensher, 2013; Ready, Champ, & Lawton, 2010). Following Beck, Rose, & Hensher (2013), the choice data were calibrated for certainty by weighting the models using responses to a numerical follow-up certainty question that appeared after each choice set. We ran the independent models ten times using different random starting values and chose those models yielding the lowest log-likelihood values for the transfer validity and reliability assessment.[44]

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[42] Modeling correlations among random coefficients yields more accurate estimates of WTP or WTA (Hess & Train, 2017).

[43] Such interactions can improve transfer accuracy (e.g., Brouwer et al., 2015). However, this does not hold in all cases (e.g., Ostberg, Cecilia, & Hasselstr, 2013) and can increase errors (e.g., Johnston & Duke, 2010).

[44] We also ran models with data not calibrated for certainty and with a fixed payment parameter. For both weighted and unweighted data, likelihood ratio tests revealed that the models with log-normal payment were significantly different from, and thus preferred to, the models with fixed payment. While the specific results regarding transfer validity and reliability differed somewhat when using models not calibrated for certainty or with fixed payment, they were fairly similar and

4.2.2. Deriving market shares and compensating surplus

We derived market share and compensating surplus estimates from the RPL models using the simulation approaches of Hu, Veeman, & Adamowicz (2005) and Czajkowski, Hanley, & Lariviere (2015). Two sequential rounds of simulation were conducted yielding vectors representing empirical densities for each attribute. An initial ‘parameter simulation’ accounts for the sampling distribution of all coefficients by taking R draws from a multivariate normal distribution characterized by the RPL model’s mean and standard deviation or lower-triangular Cholesky matrix coefficients as well as variance-covariance matrix. For models with correlated random coefficients the variance-covariance matrix, used in the next round of simulation, is generated from the simulated lower-triangular Cholesky coefficients for each of the R draws. A subsequent ‘coefficient simulation’ incorporates the preference heterogeneity accounted for by the random parameters. It is completed by taking S draws from a normal distribution defined by the mean coefficients and standard deviation coefficients or variance-covariance matrix generated from each of the R draws of the ‘coefficient simulation’. R vectors of size S are generated for each random parameter. We used 2000 draws for each round of simulation.

These vectors were used to predict participation in a particular wetlands conservation program specification versus maintaining the status quo and then to calculate the associated compensating surplus.[45] For each of the $\mathrm{R} = 2000$ vectors, market shares (MS) were obtained by calculating the choice probabilities for each alternative according to Equation 4.3 (Hudson et al., 2012; Hensher et al., 2015).

$$\mathrm{MS_s} = \frac{\mathrm{e}^{\mathrm{V_s^j}}}{\sum \mathrm{e}^{\mathrm{V_s^k}}} \ \forall \ \mathrm{S} = 1, \dots, 2000 \qquad (4.3)$$

where $\mathrm{V_s^j}$ represents the $\mathrm{s^{th}}$ element of the indirect utility vector for a particular alternative program specification and $\mathrm{V_s^k}$ the $\mathrm{s^{th}}$ element of the indirect utility vector of

the conclusions of this paper were unaffected (see Appendix C5 for results related to these models).

[45] The exponent of log-normally distributed random parameters was taken after the coefficient simulation (Johnston & Duke, 2008).

the set of alternative program specifications. Similarly, compensating surplus (CS) was derived using Equation 4.4 for each of the $\mathrm{R} = 2000$ vectors (Hanemann, 1984).

$$\mathrm{CS_s} = -\frac{(\mathrm{V_s^0}\text{-}\mathrm{V_s^1})}{\lambda_\mathrm{s}} \ \forall\ \mathrm{S} = 1, \ldots, 2000 \tag{4.4}$$

where λ_s represents the $\mathrm{s^{th}}$ element of the simulated payment parameter vector and the V_s^0 and V_s^1 respectively represent the $\mathrm{s^{th}}$ elements of the indirect utility vectors for the status quo and alternative program specifications. For compensating surplus or market shares this process yields $\mathrm{R} = 2000$ vectors of size $\mathrm{S} = 2000$ estimates (i.e., 4 million in total) for each program specification. Point estimates were calculated using the ‘mean of mean’ and ‘mean of median’ approaches (Hu et al., 2005; Johnston & Duke, 2008). These approaches involved first taking the mean or median of the $\mathrm{S} = 2000$ estimates comprising each of the $\mathrm{R} = 2000$ vectors. A vector of size $\mathrm{R} = 2000$ that represents the distribution of the estimate results and the mean of this vector is the point estimate. This vector is also an input into convergent validity testing (Johnston & Duke, 2008).

4.2.3. Assessing the Validity and Reliability of Transfers

For welfare estimates, transfer validity is traditionally assessed by testing the similarity of model coefficients or mean estimates, while reliability is assessed by calculating the percent error arising from transferring the mean estimates (Johnston & Rosenberger, 2010; Rosenberger, 2015).[46] These methods are also applicable to assessing transfers of market shares.

Testing the Similarity of Choice Models

Testing whether model coefficients are equal reveals whether the entire model can be transferred across sites (Rosenberger, 2015). The null hypothesis is that the coefficients from the study (β_{SS}) and policy (β_{PS}) site models are equal.

$$\mathrm{H_0}: \beta_{\mathrm{SS}} = \beta_{\mathrm{PS}} \tag{4.5a}$$

$$\mathrm{H_1}: \beta_{\mathrm{SS}} \neq \beta_{\mathrm{PS}} \tag{4.5b}$$

[46] Mean estimates include marginal values as well as welfare estimates. For the current study, marginal values are not of interest since they are not usually calculated for market shares.

Such tests are not straightforward since model coefficients are confounded with the scale parameter, which can differ across datasets (Louviere, Hensher, & Swait, 2000). Accounting for scale involves pooling the data from the sites being compared and estimating a model with a relative scale parameter. For RPL models, this entails using trial values of the relative scale parameter to search for the pooled model with the largest log-likelihood. The results of this grid search are entered into a likelihood ratio test along with results from the independent site specific models (Swait & Louviere, 1993).

$$\text{LL Ratio Test: -2}\left(\text{LL}_{\text{Pooled}}\text{-}(\text{LL}_{\text{SS}} + \text{LL}_{\text{PS}})\right) \sim \text{X}^2 \text{ with d.f.} = \text{K} + 1 \tag{4.6}$$

We conducted our grid search using trial values ranging from 0 to 2 at intervals of either 0.05 or 0.1.[47] In contrast to the independent models run for each watershed, we only ran the models using a single set of starting values to expedite the test.

Testing for Differences in MS or CS and Calculating Transfer Error

We used traditional hypothesis tests to assess whether mean estimates of market shares or compensating surplus are equal across sites as well as equivalence tests to assess whether the difference in mean estimates falls within a certain interval (Johnston & Rosenberger, 2010). The traditional approach tests the null hypothesis that the pair of estimates is equal.[48]

$$\text{H}_0\text{: E}_{\text{SS}}\text{-E}_{\text{PS}} = 0 \tag{4.7a}$$

$$\text{H}_1\text{: E}_{\text{SS}}\text{-E}_{\text{PS}} \neq 0 \tag{4.7b}$$

The complete combinatorial method, which involves estimating the significance of the difference in the pair of estimates, was used in testing this hypothesis since it does not require normally distributed estimates (Poe, Giraud, & Loomis, 2005). This method involves estimating a p-value by calculating the difference between every element a and b of the vectors of estimates representing the empirical distribution of the

[47] For trial values between 0 and 0.5, and greater than 1.5 but less than or equal to 2, intervals of 0.1 were used. We used intervals of 0.05 for trial values ranging from 0.5 to 1.5.

[48] '*E'* represents either market share or compensating surplus estimates in hypotheses and equations.

estimates derived earlier (Equation 4.8). If the vectors are ordered such that the estimate from the study site is larger than that from the policy site ($E_{SS} > E_{PS}$), the p-value is the proportion of differences that are non-positive.

$$\left(E_{SS}^{a}\text{-}E_{PS}^{b}\right) \leq 0 \quad \forall\, a = 1, \ldots, 2000 \text{ and } b = 1, \ldots, 2000 \tag{4.8}$$

Equivalence testing is potentially better suited to assessing the validity of transfers. Since mean estimates result from different sites they are fundamentally different and not necessarily identical. As such the traditional null hypothesis, testing whether estimates are equal, is not appropriate. The basis of equivalence testing is that the mean estimates from the sites are different unless testing reveals that the difference in the estimates is within a pre-defined tolerance interval (Johnston & Rosenberger, 2010; Rosenberger, 2015). The bounds on this tolerance interval ($\theta_1$and θ_2) are calculated by multiplying the mean estimate from the policy site ($\overline{E}_{PS}$) by a chosen tolerance level ($\pm\delta\%$), which represents the acceptable level of error in percent, yielding $\theta_1 = \text{-}\delta(\overline{E}_{PS})$ and $\theta_2 = \delta(\overline{E}_{PS})$.

The equivalence test's null hypothesis is whether the difference in mean estimates from the policy and study sites is less (greater) than or equal to the lower (upper) bound of the tolerance interval (i.e., the difference is not contained within the tolerance interval).

$$H_0: \left(E_{SS}\text{-}E_{PS}\right) \leq \theta_1 \text{ or } \left(E_{SS}\text{-}E_{PS}\right) \geq \theta_2 \tag{4.9a}$$

$$H_1: \theta_1 < \left(E_{SS}\text{-}E_{PS}\right) < \theta_2 \tag{4.9b}$$

In practice, the null is divided into two sub null hypotheses relating to the tolerance interval's lower or upper bounds.

$$H_{0a}: \left(E_{SS}\text{-}E_{PS}\right) \leq \theta_1 \text{ or } \left(E_{SS}\text{-}E_{PS}\right)\text{-}\theta_1 \leq 0 \tag{4.10a}$$

$$H_{0b}: \left(E_{SS}\text{-}E_{PS}\right) \geq \theta_2 \text{ or } \left(E_{SS}\text{-}E_{PS}\right)\text{-}\theta_2 \geq 0 \tag{4.10b}$$

We tested these hypotheses using a variant of the two one-sided combinatorial (TOSC) test (Johnston & Duke, 2008). The TOSC test is an adaptation of the complete combinatorial and thus does not require normally distributed estimates. It involves taking the difference between all elements a and b that comprise the previously derived vectors of mean estimates for the study and policy sites. The bounds on the tolerance interval are then subtracted from this difference. The p-value corresponding to the first sub-hypothesis is calculated as the proportion of differences that are less than or equal to zero, while the p-value for the second sub-hypothesis is the proportion of differences that are greater than or equal to 0.

$$\left(\mathrm{E}_{\mathrm{SS}}^{\mathrm{a}}\text{-}\mathrm{E}_{\mathrm{PS}}^{\mathrm{b}}\right)\text{-}\theta_1 \leq 0 \qquad \forall\ \mathrm{a} = 1, \ldots, 2000 \text{ and } \mathrm{b} = 1, \ldots, 2000 \tag{4.11a}$$

$$\left(\mathrm{E}_{\mathrm{SS}}^{\mathrm{a}}\text{-}\mathrm{E}_{\mathrm{PS}}^{\mathrm{b}}\right)\text{-}\theta_2 \geq 0 \qquad \forall\ \mathrm{a} = 1, \ldots, 2000 \text{ and } \mathrm{b} = 1, \ldots, 2000 \tag{4.11b}$$

Though 20% is the standard tolerance level in pharmaceutical research, such a convention has not been established for benefit transfer (Johnston & Duke, 2008). As such we instead used Czajkowski & Ščasný's (2010) variant of the TOSC test to estimate the tolerance level at which mean estimates are considered equivalent given a chosen level of statistical significance (95% for this study). The variant involves using a grid search to determine the tolerance level at which both sub-hypotheses are rejected.

We calculated both directional and non-directional transfer errors (Kaul et al., 2013). Typically errors are calculated using Equation 4.12, which produces directional errors since the denominator depends on which watershed is assumed to be the policy site.

$$\text{Transfer Error (\%)} = 100 \times \left|\frac{(\bar{\mathrm{E}}_{\mathrm{SS}}\text{-}\bar{\mathrm{E}}_{\mathrm{PS}})}{\bar{\mathrm{E}}_{\mathrm{PS}}}\right| \tag{4.12}$$

A non-directional alternative, introduced by Chattopadhyay (2003), is to treat the denominator as the average of the values at the two sites (Equation 4.13).

$$\text{Non-Directional Error (\%)} = 100 \times \left|\frac{(\bar{\mathrm{E}}_{\mathrm{SS}}\text{-}\bar{\mathrm{E}}_{\mathrm{PS}})}{(\bar{\mathrm{E}}_{\mathrm{SS}}+\bar{\mathrm{E}}_{\mathrm{PS}})/2}\right| \tag{4.13}$$

Finally, we used ordinary least squares (OLS) regressions to help disentangle the factors influencing transfer errors and tolerance levels for market shares as well as compensating surplus (following Johnston & Duke, 2009). This analysis involved separately pooling the transfer errors or tolerance levels and then regressing them on variables representing the levels taken by attributes for each specification and the transfer's direction.

4.2.4. Comparing Sample Characteristics

The two samples were compared in terms of their socio-demographics and the characteristics of the land owned by respondents. Testing was completed to compare these characteristics across each watershed. We used chi^2 or Fishers exact tests for categorical and binary data, while we used Wilcoxon rank-sum tests for ordinal and continuous data.

4.3. Data

The data for this study comes from two case studies eliciting preferences for incentive-based wetlands restoration programs on private land conducted in 2013. We conducted these studies in the Grand and Upper Thames watersheds, two neighbouring river basins in Southern Ontario, Canada (Figure 4.1). The area of wetlands in this region has declined by over 70% since European colonization due to growth in the population and area devoted to agriculture (Ducks Unlimited Canada, 2010). Both watersheds are part of the Lake Erie Basin, though the Upper Thames initially empties into Lake St. Clair via the Lower Thames River. At 6800 square kilometers (km^2), the Grand River watershed is twice the size of the Upper Thames which is 3420 km^2. The watersheds are highly populated with the Upper Thames home to half a million residents living in urban areas covering 10% of the watershed's area and the Grand nearly 1 million residents living in urban areas covering 6% of the watershed (although the two watersheds have similar population densities). Agriculture is the dominant land use in both watersheds, respectively accounting for 70% and 75% of the area of the Grand and Upper Thames watersheds. Forest cover is highest in the Grand (19% compared to 11% in the Upper Thames), as is wetland cover (10% compared to 5% in the Upper Thames). At 3%, meadow cover is highest in the Upper Thames compared to less than 1% in the Grand (Grand River Conservation Authority, 2008, 2014, 2016; Upper Thames River Conservation Authority, 2012, 2015).

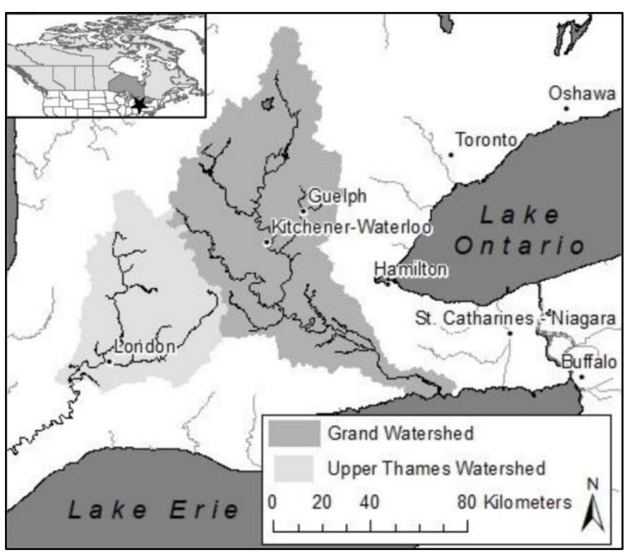

Figure 4.1: The Location of the Grand and Upper Thames Watersheds

The choice experiment used in the two case studies was initially developed to examine landowner preferences for wetlands conservation in the nearby Credit River watershed in the spring of 2012 (Trenholm et al., 2013). A literature review, several focus groups, and meetings with the watershed's conservation authority were used to inform the initial survey and choice experiment. The same choice experiment was then implemented independently in the Grand and Upper Thames River watersheds one year later (Trenholm et al., 2017). The questionnaires implemented in 2013 were very similar. However, certain non-choice experiment questions differed from those sent in 2012 as did the style of the certainty questions that appeared after each choice set. A textual certainty scale was used in 2012 and a numerical certainty scale was used in 2013 (1=Not at all certain to 10=Very certain). To detect respondents who were not stating their true preferences a protest screening question appeared at the end of the choice experiment. The attributes used in the choice experiment included area converted, conversion activity, technical help, public recognition and payment to landowner (Table 4.1; see Appendix C2 for a copy of the choice experiment preamble and the first choice set).

Table 4.1: Attributes and Levels

Attribute	Variable Names	Description	Levels	Coding
Area converted	Acres	Area of land converted to wetlands conservation	0.5 acres 1 acre 1.5 acres	Numerically coded using actual values
Conversion activity	Meadow Trees Wetland	Land can be converted to meadow or trees to help retain nearby wetlands, or directly into wetland	Meadows Trees Wetland	Effects coded
Technical help	Technical	Technical advice from experts, the government or other groups	No Yes	Dummy coded (No = 0; Yes = 1)
Public recognition	Recognition	Signage on property, stewardship banquets, and awards	No Yes	Dummy coded (No = 0; Yes = 1)
Payment to landowner	Payment	Annual payment	\$0 \$50 \$100 \$150 \$200 \$250	Numerically coded using actual values

A main effects fractional factorial experimental design composed of 72 different alternatives was generated using SAS 9.3 software (Kuhfeld, 2010). These alternatives were allocated to 36 choice sets, with each set containing 2 alternatives and a status quo option. A blocking variable was included in the design to allot the choice sets to 6 blocks. The resulting design was examined for dominance and a few changes made yielding a final design with a D-efficiency of 90.8%.

We coded the variables following a mixed coding scheme (see final column of Table 4.1). Using effects codes for the conversion activity variables ensures that they are not aliased with the ASC. This coding scheme means that, similar to Kaczan, Swallow, & Adamowicz (2013), the ASC term can be used to represent the utility associated with the status quo (i.e., no area converted, conversion activity, technical help, public recognition, or payment).

Private landowners located in and near the Grand and Upper Thames watersheds were surveyed during the spring of 2013. Canada Post's Admail (Canada Post, 2015) service was used to send survey packages to 5,937 and 4,149 rural non-farm households in the Grand and Upper Thames watersheds, respectively. These households were located along rural routes in rural postal codes that intersected with each watershed. Surveys were returned from 942 households in the Grand watershed and 773 households in the Upper Thames watershed. This yielded response rates of 16% and 19%, respectively, in the Grand and Upper Thames watersheds. While these rates are fairly low, they are within the range of those reported for similar choice experiment studies and other Canadian landowner surveys (e.g., Rossi, Carter, Alavalapati, & Nowak, 2011; Yu & Belcher, 2011). The data was cleaned to remove observations from respondents who: were from non-targeted postal codes; did not answer key questions; owned less than 1.5 acres of land; selected the same non-status quo option in all choice sets (serial non-participation); or who selected the status quo option in all sets and were identified as protesters (protest screening rules are similar to Meyerhoff, Mørkbak, & Olsen, 2014). After cleaning, 405 returns from the Grand watershed and 354 returns from the Upper Thames watershed were used in the analysis.

4.4. Results

4.4.1. Respondent Characteristics

Tests reveal no statistically significant differences in socio-demographics between the two watersheds (Table 4.2). Both samples had more male than female respondents, the largest age group was 45 to 64 with a mean age in the mid-50's, the majority were employed full or part-time, most had a post-secondary degree, and the majority made over $75,000 with the largest income group earning $100,000 or more.

Table 4.2: Respondent Characteristics and Features of their Land

Characteristic	Data Type	Grand (n = 405)	Upper Thames (n = 354)	Test Results[a]
Gender				
Male	Binary	66%	71%	
Female		34%	29%	
Age (Adults)				
Under 25	Ordinal	1%	1%	
25 to 44		20%	18%	
45 to 64		55%	53%	
65 or older		24%	29%	
Mean (years)	Continuous	55.2	56.4	
Highest level of education				
Less than High School	Ordinal	13%	5%	
High School		22%	30%	
Post-secondary		65%	64%	
Employment status				
Employed	Categorical	69%	72%	
Unemployed		1%	1%	
Not in labour force		30%	27%	
Household Income				
Under $10,000	Ordinal	2%	0%	
$10,000 to $29,999		4%	5%	
$30,000 to $49,999		14%	16%	
$50,000 to $74,999		20%	21%	
$75,000 to $99,999		20%	22%	
$100,000 and over		40%	36%	
Land Cover				
Has forests	Binary	61%	55%	‡
Has meadows	Binary	28%	16%	‡‡‡
Has wetlands	Binary	63%	43%	‡‡‡
Has crop, pasture, or orchard (i.e., agricultural land cover)	Binary	66%	77%	‡‡‡
Land Use				
Primary land use is agriculture or forestry	Categorical	45%	59%	‡‡‡
Primary land use is residential		52%	38%	
Primary land use is other		3%	3%	
Generated income from land in past 5 years	Binary	53%	70%	‡‡‡
Farm or forest producer[b]	Binary	39%	56%	‡‡‡
Area of Land Holdings				
5 acres or less	Ordinal	27%	21%	‡‡‡
5 to 30 acres		27%	15%	
30< to 100 acres		31%	36%	
More than 100 acres		16%	29%	
Mean (acres)	Continuous	66.2	111.9	‡‡‡

[a] ‡ and ‡‡‡ indicate a difference across the Grand and Upper Thames watersheds at the 90% and 99% levels of significance

[b] This variable was generated from farm or forest related questions in SPSS 23 software using non-linear principal component analysis (Linting & van der Kooij, 2012) and two step cluster analysis.

Unlike socio-demographics, respondent land characteristics differed significantly across the two watersheds (Table 4.2). In terms of land cover, the incidence of forest, meadow, and wetland cover is highest in the Grand. Conversely, agriculture-related land cover was more prevalent in the Upper Thames. Similarly, the primary land use was almost evenly split between residential and agriculture/forestry in the Grand, and skewed more towards agriculture/forestry in the Upper Thames. The majority of respondents in both watersheds reported earning income from their land in the past 5 years, though those in the Upper Thames were more likely to earn such income. Unsurprisingly, based on farming and forestry related questions respondents were more likely to be clustered into a farm or forest producer group in the Upper Thames. Finally, property sizes were on average larger in the Upper Thames.

4.4.2. Random Parameters Logit Models and Testing Model Similarity

We initially assessed whether models with correlated and uncorrelated random coefficients significantly differed. For both watersheds, likelihood ratio tests reject the null hypothesis of uncorrelated random coefficients (Grand: $X^2_{(21)} = 78.85 \text{ with } p < 0.01$; Upper Thames: $X^2_{(21)} = 47.15 \text{ with } p < 0.01$). Thus the models with correlated random coefficients are preferred to those with independent random coefficients. The R^2 values suggest that the independent models are of decent fit according to criteria in Hensher, Rose, & Greene (2015), with all mean and several lower-triangular Cholesky coefficients significant (Table 4.3). Regarding the mean taste parameters, the ASC parameter indicates that respondents in the Upper Thames watershed are willing to enroll all else equal. Enrolling larger areas is disliked by respondents in both watersheds. In terms of the conversion activity, respondents in the Grand and Upper Thames watersheds have a preference for trees over wetland or meadow. Tastes for the other two activities differ by watershed with those in the Upper Thames having a preference for wetland over meadow and those in the Grand preferring meadow to wetland. Respondents in both watersheds favour technical help and dislike public recognition. Transforming the log-normal payment parameter reveals that respondents in both watersheds favour higher amounts of compensation.

Table 4.3: Random Parameter Models by Watershed

Variable[a]	Grand	Upper Thames
Mean		
ASC	1.0888*	1.2019**
	(0.5851)	(0.5100)
Acres	-0.7655***	-0.7383***
	(0.2561)	(0.2591)
Conversion Activity:	-1.3125***	-0.7964***
Wetland	(0.2918)	(0.2378)
Conversion Activity:	1.6239***	1.6996***
Trees	(0.2461)	(0.2424)
Conversion Activity:	-0.3115	-0.9032***
Meadow[b]	(0.2027)	(0.2156)
Technical help (Yes)	1.2360***	0.9252***
	(0.2391)	(0.2331)
Recognition (Yes)	-0.5786***	-0.6846***
	(0.2138)	(0.1951)
ln(Annual payment)	-5.1530***	-5.2494***
	(0.2152)	(0.2566)
Correlation (Lower-Triangular of the Cholesky Matrix)		
ASC × ASC	6.1532***	-5.5341***
	(0.9368)	(0.8283)
Acres × ASC	1.0301**	-0.5943
	(0.4175)	(0.3864)
Wetland × ASC	0.7533	0.1104
	(0.4724)	(0.3672)
Trees × ASC	-0.0765	-0.6936*
	(0.3628)	(0.3714)
Technical × ASC	-0.1031	0.0914
	(0.3325)	(0.3427)
Recognition × ASC	-0.0008	-0.1850
	(0.3520)	(0.2841)
Payment × ASC	0.0753	-0.0086
	(0.1313)	(0.1419)
Acres × Acres	1.8544***	1.7954***
	(0.4690)	(0.4395)
Wetland × Acres	0.3116	0.4186
	(0.5977)	(0.4379)
Trees × Acres	0.0422	-0.1288
	(0.4079)	(0.3926)
Technical × Acres	0.0369	-0.7505*
	(0.3901)	(0.3983)
Recognition × Acres	-0.3120	0.1948
	(0.4422)	(0.3285)
Payment × Acres	0.0970	-0.3266**
	(0.1346)	(0.1308)
Wetland × Wetland	2.9955***	-2.3003***
	(0.3964)	(0.3338)
Trees × Wetland	-1.8523***	1.2049***
	(0.3068)	(0.2678)

Variable[a]	Grand	Upper Thames
Technical × Wetland	0.1832	-0.4707*
	(0.2723)	(0.2480)
Recognition × Wetland	-0.2222	-0.1737
	(0.2533)	(0.2181)
Payment × Wetland	0.1319	-0.2070*
	(0.1026)	(0.1183)
Trees × Trees	1.4925***	-1.5489***
	(0.2278)	(0.2223)
Technical × Trees	-0.6091**	0.3874
	(0.2960)	(0.2890)
Recognition × Trees	-0.5236*	0.1535
	(0.2977)	(0.2378)
Payment × Trees	-0.0394	-0.4138***
	(0.1080)	(0.1283)
Technical × Technical	-1.0209***	0.9957**
	(0.3550)	(0.4237)
Recognition × Technical	0.1298	0.1460
	(0.4228)	(0.3798)
Payment × Technical	0.8827***	-0.0807
	(0.1566)	(0.1235)
Recognition × Recognition	1.1546***	-0.1779
	(0.3919)	(0.3333)
Payment × Recognition	-0.9801***	1.2445***
	(0.1452)	(0.1867)
Payment × Payment	-0.0577	-0.3365***
	(0.1511)	(0.1109)
Model Statistics		
Log-Likelihood	-1248.34	-1113.83
Observations	7263	6363
Pseudo R^2	0.36	0.35

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

[a] Standard errors appear in brackets below the corresponding parameter estimate.

[b] As activity variables are effects coded, meadow parameter derived as negative of other activity parameters. The corresponding standard errors were estimated via the Delta method.

The elements of the lower-triangular of the Cholesky matrix represent each random parameter's estimated contribution to the set of standard deviation parameters (Hensher et al., 2015). The diagonal elements show a random parameter's contribution to its own standard deviation parameter net of the influence of other random parameters, while the off-diagonal elements indicate contributions to standard deviation from correlations with other random parameters. All diagonal elements are significant except those for the public recognition and payment variables in the Upper Thames and Grand models, respectively. The significant off-diagonal elements estimated for our models indicate that preferences for certain random parameters are not independent.

Specifically, the Upper Thames model yields significant off-diagonal elements for: conversion activity as trees and the ASC as well as conversion activity as wetlands; technical help and acres as well as conversion activity as wetlands; and log-normal payment and acres, conversion activity as wetlands, conversion activity as trees, as well as recognition. For the Grand model the significant elements include: acres and the ASC; conversion activity as trees and conversion activity as wetlands; technical help and conversion activity as trees; recognition and conversion activity as trees; and log-normal payment and technical help as well as recognition.

We also derived the variance-covariance matrix and standard deviation parameters from the lower-triangular Cholesky matrix using the Delta method (see Appendix C3). All of the estimated standard deviation parameters are significant for both models indicating that preferences for each attribute are heterogeneous in both watersheds. Significant positive covariances were observed between the ASC and conversion activity as trees parameters for the Upper Thames model and the ASC and acres parameters for the Grand model. We observed significant negative covariances between the acres and log-normal payment parameters, conversion activity as trees and conversion activity as wetland parameters, and technical help and conversion activity as trees parameters for the Upper Thames model. For the Grand model, we observed significant negative covariances between the conversion activity as trees and conversion activity as wetland parameters, technical help and conversion activity as trees parameters, log-normal payment and public recognition parameters, and log-normal and technical help parameters.[49]

Pooling the data from the two watersheds and running the grid search revealed that a trial value of the relative scale parameter of 1.2 ($\sigma_{\mathrm{Grand}}/\sigma_{\mathrm{Upper\ Thames}}$) results in the largest log-likelihood (-2417.82). The likelihood ratio test using the log-likelihoods from the independent and pooled models reveals that the Grand and Upper Thames models are significantly different ($\mathrm{X}^2_{(36)} = 111.31 \text{ with } \mathrm{p} < 0.01$).

[49] Positive (negative) covariances between two random parameter's indicate that larger values along a random parameter's distribution correspond with larger (smaller) values along the other random parameter's distribution (Hensher, Rose, & Greene, 2015).

4.4.3. Market Share and Compensating Surplus Estimates

The ‘mean of mean’ approach resulted in exploding compensating surplus, which is a common problem with estimates generated from models with log-normally distributed payment parameters (Thiene & Scarpa, 2009). Thus, following Johnston & Duke (2008) and Johnston, Schultz, Segerson, Besedin, & Ramachandran (2012) we used estimates generated from the ‘mean of median’ approach since it resulted in more sensible compensating surplus estimates (akin to those derived from a model with fixed payment). Although we observed more reasonable compensating surplus estimates, the market share estimates derived from the ‘mean of median’ approach were more variable than their ’mean of mean’ counterparts (‘mean of mean’ output equivalent to Figures 4.1 and 4.2 as well as Tables 4.4 and 4.5 is provided in Appendix C4).

Market share estimates derived from the two models are closely aligned for all possible program specifications as are the compensating surplus estimates (Figure 4.2). Indeed the Pearson correlation coefficients are 0.92 for market shares and 0.96 for compensating surplus. In general, the market share estimates suggest that many respondents would participate. However, market shares are quite variable ranging from just over 30% to near 100% depending on the program specification. Compensating surplus is also variable, ranging from around -$400 per year/household to $130 per year/household depending on the specification.

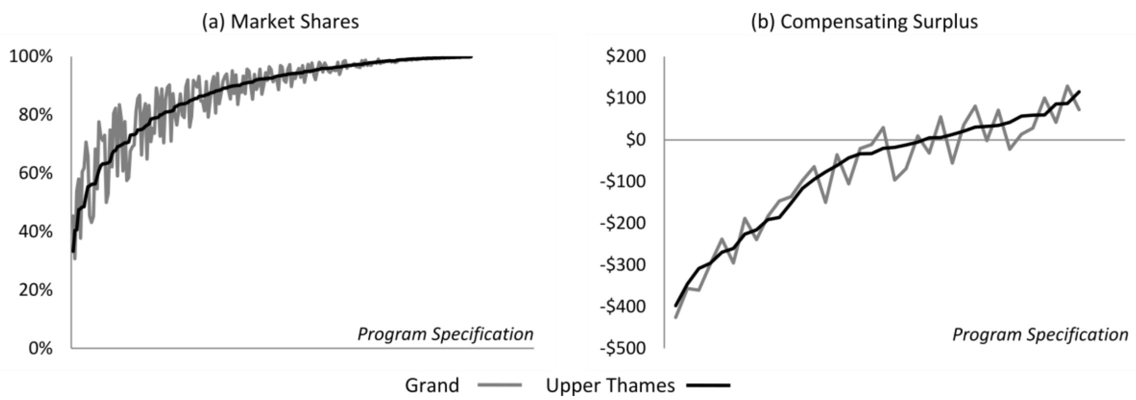

Figure 4.2: Market Share (a) and Compensating Surplus (b) Estimates
Note: for both panels the x-axis represents all possible program specifications (e.g., for panel (a) a point on this axis represents a program with 0.5 acres converted to wetlands with no technical help or recognition and a payment of $50, etc., while the points on this axis in panel (b) are similar though do not include a payment component). The data were sorted in ascending order according to the MS or CS values estimated for the Upper Thames.

4.4.4. Transfer Validity and Reliability

The range in directional errors for transfers of market share estimates (MS) is much narrower than the corresponding range in errors for transfers of compensating surplus (CS) (Table 4.4). Similarly, the mean and median of the directional errors for transfers of market shares are much lower than the related averages for transfers of compensating surplus. The non-directional errors reflect these results. As with the errors, the range in tolerance levels calculated for market shares is tighter and the averages lower relative to those calculated for compensating surplus. Finally, the results of the complete combinatorial tests are the same for transfers of market shares and compensating surplus — none of the pairs of estimates differ at the 99%, 95%, or 90% levels of significance.

Table 4.4: Summary of Reliability and Validity Tests

Transfer	Transfer Errors (%)				Tolerance Levels (%)				Complete Combinatorial
	Mean	Median	Low	High	Mean	Median	Low	High	
Directional									
MS: Grand to Thames	5	3	0	36	24	15	1	133	N/A
MS: Thames to Grand	5	2	0	31	24	16	1	142	
CS: Grand to Thames	141	52	1	879	591	266	79	3227	
CS: Thames to Grand	124	56	1	1894	570	232	75	7977	
Non-Directional									
MS: Grand and Thames	5	3	0	31	N/A				0*, 0**, 0***
CS: Grand and Thames	135	54	1	1120					0*, 0**, 0***

*, **, and *** indicate the number of pairs of estimates that are different at the 90%, 95%, and 99% levels of significance, respectively

Two sample Wilcoxon rank sum tests suggest that the distributions of directional errors, non-directional errors, and tolerance levels differ significantly by type of transfer, although the distributions do overlap somewhat (Figure 4.3).[50] The boxplots show that directional errors, non-directional errors, and tolerance levels calculated for market shares are clearly smaller and less variable than those calculated for compensating

[50] The p-values for these tests are <0.01 for directional errors regardless of direction, <0.01 for non-directional errors, and <0.01 for tolerance levels regardless of direction. The null hypothesis that the distributions are equal is rejected in all cases.

surplus. In addition, these plots appear to show that transfers of compensating surplus and market share estimates are similarly affected by transfer direction since the distributions of the directional errors and tolerance intervals for transfers to the Upper Thames overlap with transfers to the Grand. Two sample Wilcoxon rank sum tests confirm this finding for both types of transfer.[51] However, for compensating surplus the means of the errors and tolerance levels in Table 4.4 are slightly larger for transfers to the Upper Thames than to the Grand (medians are not similarly impacted). For market shares, the means and medians of the errors and tolerance levels are identical, or nearly so, by transfer direction.

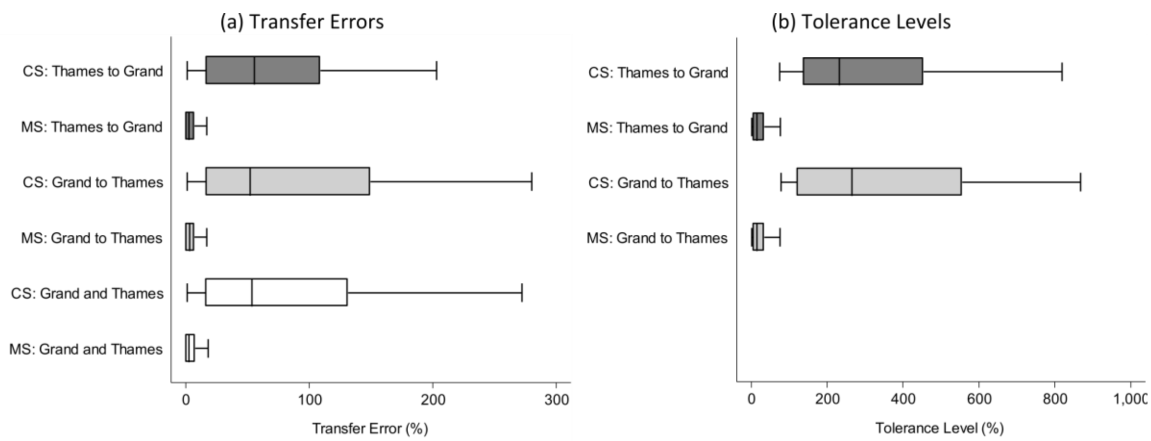

Figure 4.3: Boxplots of Transfer Errors and Tolerance Levels
Note: outliers not plotted; non-directional errors are white and directional errors are differing shades of grey.

While these comparisons provide some insight into the impact of transfer direction, they treat all errors and tolerance levels the same since they ignore the particulars of the program specification being transferred. A simple one-to-one comparison of the same specification by transfer direction reveals that transfers to the Grand result in larger errors than transfers to the Thames in 56% of cases for market shares and 44% of cases for compensating surplus (detailed output available from the authors upon request). Tolerance levels for transfers to the Grand yield larger levels than transfers to the Thames in 25% of cases for market shares and 44% of cases for compensating surplus (transfers of market shares to the Grand and transfers to the Thames result in identical tolerance levels in 52% of cases).

[51] For transfers of compensating surplus the p-values are 0.76 for errors and 0.59 for tolerance levels, while they are 0.99 and 0.97 for transfers of market shares for errors and tolerance levels, respectively. The null hypothesis of distribution equality is not rejected in all cases.

The OLS regression does account for the program specification and site treatment (Table 4.5).[52] Errors and tolerance levels calculated for compensating surplus are significantly larger for specifications involving conversion of land to wetlands or meadow, and lower for specifications involving conversion to trees. In the case of market shares, directional and non-directional errors are significantly lower for specifications that involve smaller areas, converting land to trees, technical help, and higher payments. These errors are significantly higher for specifications that involve larger areas, converting land to wetland or meadow, smaller payments, and do not involve public recognition. Market share tolerance levels are similarly affected. Transfer direction does not significantly influence errors or tolerance levels (reflecting the similarities noted in Table 4.4 and Figure 4.3). Our regression results suggest that compensating surplus and market shares are differently affected by transfer characteristics.

[52] Separate regressions were conducted for market shares and compensating surplus due to differing independent variables (i.e., payment). The dependent variables were transformed via natural log to better meet assumptions. The independent variables are all effects coded.

Table 4.5: Regression of Errors and Tolerance Levels on Transfer Characteristics for Transfers Based on the "Mean of Median" Approach[a]

Variable	Directional Errors		Tolerance Levels		Non-Directional Errors	
	MS	CS	MS	CS	MS	CS
Constant	0.3744***	3.8456***	2.5277***	5.6791***	0.3734***	3.8801***
	(0.0347)	(0.1083)	(0.0076)	(0.0918)	(0.0496)	(0.1665)
Area:	-0.2888***	-0.0184	-0.2620***	-0.0726	-0.2885***	0.0213
0.5 ac	(0.0490)	(0.1532)	(0.0107)	(0.1298)	(0.0701)	(0.2355)
Area:	-0.0142	0.1862	-0.0067	0.1369	-0.0142	0.1489
1 ac	(0.0490)	(0.1532)	(0.0107)	(0.1298)	(0.0701)	(0.2355)
Area:	0.3030***	-0.1678	0.2687***	-0.0643	0.3027***	-0.1702
1.5 ac[b]	(0.0490)	(0.1532)	(0.0107)	(0.1298)	(0.0701)	(0.2355)
Activity:	0.9291***	0.5833***	0.7937***	0.4852***	0.9288***	0.7049***
Wetland	(0.0490)	(0.1532)	(0.0107)	(0.1298)	(0.0701)	(0.2355)
Activity:	-2.3458***	-1.6967***	-1.4089***	-1.0042***	-2.3449***	-1.7333***
Trees	(0.0490)	(0.1532)	(0.0107)	(0.1298)	(0.0701)	(0.2355)
Activity:	1.4167***	1.1134***	0.6152***	0.5190***	1.4160***	1.0284***
Meadow[b]	(0.0490)	(0.1532)	(0.0107)	(0.1298)	(0.0701)	(0.2355)
Technical	-0.7188***	-0.1604	-0.3783***	-0.0266	-0.7184***	-0.1113
help: Yes	(0.0347)	(0.1083)	(0.0076)	(0.0918)	(0.0496)	(0.1665)
Technical	0.7188***	0.1604	0.3783***	0.0266	0.7184***	0.1113
help: No[b]	(0.0347)	(0.1083)	(0.0076)	(0.0918)	(0.0496)	(0.1665)
Recognition:	0.1787***	-0.0251	0.1831***	-0.0449	0.1784***	0.0365
Yes	(0.0347)	(0.1083)	(0.0076)	(0.0918)	(0.0496)	(0.1665)
Recognition:	-0.1787***	0.0251	-0.1831***	0.0449	-0.1784***	-0.0365
No[b]	(0.0347)	(0.1083)	(0.0076)	(0.0918)	(0.0496)	(0.1665)
Payment:	1.1867***		0.9913***		1.1844***	
$0	(0.0775)		(0.0170)		(0.1109)	
Payment:	0.7892***		0.5550***		0.7887***	
$50	(0.0775)		(0.0170)		(0.1109)	
Payment:	0.2203***		0.1256***		0.2206**	
$100	(0.0775)		(0.0170)		(0.1109)	
Payment:	-0.2260***		-0.2478***		-0.2253**	
$150	(0.0775)		(0.0170)		(0.1109)	
Payment:	-0.7817***		-0.5678***		-0.7808***	
$200	(0.0775)		(0.0170)		(0.1109)	
Payment:	-1.1885***		-0.8563***		-1.1876***	
$250[b]	(0.0775)		(0.0170)		(0.1109)	
Grand to	0.0022	0.0681	0.0015	0.0682		
Thames	(0.0347)	(0.1083)	(0.0076)	(0.0918)		
Thames to	-0.0022	-0.0681	-0.0015	-0.0682		
Grand[b]	(0.0347)	(0.1083)	(0.0076)	(0.0918)		
n	432	72	432	72	216	36
R^2	0.89	0.67	0.99	0.49	0.89	0.66

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

[a] Standard errors appear in brackets below the associated parameter estimates.

[b] Parameter estimate calculated as the negative of the associated parameters. The corresponding standard error was estimated using the Delta method.

4.5. Discussion and Conclusion

The percent errors estimated for transfers of compensating surplus are in the range of those reported in the literature while those resulting from transfers of market shares are much smaller. In their comprehensive review of 38 convergent validity studies that used WTP estimated from a variety of original research techniques, Rosenberger (2015) finds that value transfer yields mean and median directional errors of 140% and 45%, respectively, with a range of 0% to 7496%. Function transfer results in even lower directional errors ranging from 0% to 929% with a mean of 65% and median of 36%. The directional errors resulting from our transfers of compensating surplus ranged from 1% to 1894%, while the errors resulting for our transfers of market shares ranged from 0% to 36%. For compensating surplus, the mean of these transfer errors is either 124% or 141% depending on transfer direction while the median is either 52% or 56%. In the case of market shares the averages are much lower with the mean being 5% regardless of transfer direction, and median of 2% or 3% depending on the transfer's direction. Additionally, nearly half of the transfers reviewed by Rosenberger (2015) fail the complete combinatorial test, while none of our transfers fail the same test for compensating surplus or market shares. Finally, the likelihood ratio test revealed that the RPL models on which the transfers are based are statistically different. We are not surprised by this finding since the large number of parameters estimated for each model makes it likely that some of them will differ significantly across models. Rosenberger (2015) found 44% of such tests have rejected the null hypothesis of parameter or model equality in past studies.

Our transfers may differ in reliability and validity from those reviewed by Rosenberger (2015) for several reasons. First, the studies reviewed by Rosenberger (2015) all involved transfers of WTP which may not yield the same results as transfers of WTA, let alone market shares. Choice experiments have also been found to generate larger errors than other original research techniques (Kaul et al., 2013). Other methodological differences from the reviewed studies can affect convergent validity testing too. For example, using compensating surplus and market share estimates derived via the 'mean of median' approach yields somewhat different results than the 'mean of mean' approach although trends are similar (see Appendix C4). Furthermore, as noted by Rosenberger (2015) studies of benefit transfer reliability and validity may be more experimental than actual policy analysis since they may compare values that would not be compared in practice. Finally, transfer accuracy depends on site differences. The Grand and Upper Thames watersheds have similar geography and the socio-demographic characteristics of the two samples were also very similar (although respondent's owned land characteristics differed significantly).

The results show that percent errors and tolerance levels for transfers of market shares are much lower than those arising from transfers of compensating surplus. As expected, transfers of market shares are more valid and reliable than transfers of compensating surplus. Errors and tolerance levels generated from transfers of market shares are also less variable. This is not unexpected given that market share estimates are by definition bounded by 0% and 100% which limits the magnitude and variability of errors and tolerance levels. Compensating surplus estimates are not similarly bounded and therefore the associated errors and tolerance levels are larger in magnitude and more variable. Interestingly, all pairs of estimates were deemed equal by the complete combinatorial test for transfers of compensating surplus and market shares. On the surface this result seems counter to the finding that transfers of compensating surplus are less accurate — we might expect that a larger proportion of compensating surplus estimates would differ statistically across sites. However, the complete combinatorial test relies on a classical null hypothesis and the likelihood of rejecting the null of equal estimates increases when variance is large or the difference in means small (Kristofersson & Navrud, 2005; Johnston & Duke, 2008). Calculating the coefficient of variation for each estimate reveals that compensating surplus is generally much more variable than market shares. The high variance increases the likelihood that compensating surplus estimates are found equal. Although conversely, transfer errors reveal that the difference in market share estimates is smaller than the difference in compensating surplus which increases the likelihood that market share estimates are found equal.

The regression analysis provides some insight into situations where transfers are more accurate. For example, in the case of market shares directional errors are lowest for program specifications characterized by 0.5 acres, the conversion activity being trees, technical help offered, no recognition offered, and payment of $250. In terms of compensating surplus, fewer variables are significant which suggests that program specifications do not affect errors or tolerance levels to the same extent. Thus, the accuracy of transfers of market shares or compensating surplus are differently influenced by program specification. However, the regression models did not include the same variables and by extension the same number of observations. The direction of the transfer was not significant in any regression.

While transfers of market shares appear more valid and reliable than transfers of compensating surplus, whether the lower error is acceptable for policy analysis depends on the project (Johnston & Duke, 2008). In general, analyses needing more accuracy demand lower errors. However, given that market shares are less prone to high errors by definition it is worth asking whether transfers of these estimates should meet a higher threshold than transfers of welfare estimates in order to be considered accurate. This means lower transfer errors and in the context of equivalence testing a lower tolerance level. Nevertheless, the decision to use transfers in policy analysis rather than original research depends on the opportunity cost involved in making a mistake (Allen & Loomis, 2008). This opportunity cost in turn depends in part on the likelihood of making the wrong decision, which appears low for transfers of market shares.

This study contributes to the literature by examining the accuracy of transferring predicted participation market shares derived from choice experiment data. To provide context, these results are compared with the accuracy of transferring compensating surplus generated from the same data. The main finding is that transfers of market shares appear quite reliable and valid, especially when placed in the context of our transfers of compensating surplus. However, given the difference in how each estimate is calculated the threshold at which transfers of market shares could be considered valid and reliable likely differs from that of welfare estimates. Investigating this threshold should be the subject of additional inquiry. Additional avenues of research involve investigating whether findings related to transfers of economic values also apply to transfers of market shares. Further research specific to market shares would provide more insight into when market share transfers are likely to be more or less accurate. For instance, our work represents a best-case scenario, in that the same alternatives were used at the study and policy sites and we only examined the adoption decision of landowners which is a subset of possible market shares. Assessing market share transfers between sites with different sets of alternatives, or transfers of the larger set of market shares are other potential avenues of future research. Finally, a structural approach to applied benefit transfer, which involves calibrating an indirect utility function from available data and using it to predict estimates at the policy site, would be ideal for transferring both market shares or economic values and deserves examination (Smith, Houtven, & Pattanayak, 2002; Smith, Pattanayak, & Houtven, 2006). Regardless, our examination of the issue suggests that transferring market shares has potential for use in policy analysis.

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Chapter 5.

Reconciling Quantitative Attributes with Different Levels When Transferring Willingness to Pay Elicited from Choice Experiments: Evidence from Benefit Transfers between Four Canadian Watersheds

A version of this chapter has been submitted for peer review to Environmental and Resource Economics as Trenholm, R., Lantz, V., Knowler, D., and Haider, W. "Reconciling Quantitative Attributes with Different Levels When Transferring Willingness to Pay Elicited from Choice Experiments: Evidence from Benefit Transfers between Four Canadian Watersheds". I co-led the design of this research, though led the transfer portion, and was the co-lead on the fieldwork (with members of the supervisory committee as well as three masters students: Toni Anderson; Monica McKendy; and David Angus). I authored nearly all of the text and conducted all of the data analyses.

Abstract

Benefit transfers require the reconciliation of good or service definitions across policy and study sites. In this study we assessed three alternatives, based on separate linear and quadratic model specifications, for reconciling quantitative choice experiment attributes with levels that differ across sites. Reconciliation of such differences is straightforward for linear relationships since values are constant across levels. For quadratic relationships there are multiple approaches to reconciliation since willingness to pay (WTP) is not constant, including those rooted in 'relative' or 'absolute' preferences that involve matching levels according to their order in the set of levels or their quantity, respectively. Our data is from choice experiments eliciting WTP for changes in four Canadian watersheds, with the levels of one of the attributes differing by site. We assessed the validity and reliability of each reconciliation approach and used these results to compare the performance of each approach. In general, the linear specification yields more valid and reliable transfers than either quadratic approach for transfers of compensating surplus though not necessarily for marginal WTP. Furthermore, transfers of marginal WTP and compensating surplus based on 'relative' preferences are more valid and reliable than those based on 'absolute' preferences. However, for welfare estimates the quadratic approaches yield more similar results when the attributes needing reconciliation have more similar levels.

Keywords: benefit transfer; attribute reconciliation; choice experiment; willingness to pay; relative preferences; absolute preferences; convergent validity

5.1. Introduction

Benefit transfer is widely used to assign monetary values to changes in non-market goods or services (Johnston and Rosenberger 2010). The technique involves transferring monetary values across space, time, or populations from one or more study sites (SS) to a policy site (PS). There are two main procedures: 1) unit value transfer involves transferring mean or median economic values, either adjusted for differing site characteristics, or not; and 2) benefit function transfer involves transferring functions that relate site characteristics to the economic values. Both of these approaches are subject to a range of errors, including generalization error that stems from transferring values across dissimilar study and policy sites. Convergent validity studies have found percent errors that range from 0% to over 7000% (Rosenberger 2015). These studies assess benefit transfer by conducting the same original valuation research at different case study sites and then assessing the validity and reliability of transfers by calculating percent errors and testing the similarity of models or economic values. In general, a key factor contributing to transfer accuracy is the similarity of study and policy sites (Bateman et al. 2011; Kaul et al. 2013).

To maintain a direct comparison, convergent validity and reliability assessments of benefit transfer usually value the same change at different case study sites (e.g., for choice experiments, the use of the same attributes and levels). However, study sites are inherently different which means that valuing somewhat different changes in the non-market good or service, such as using different attributes or levels, better reflects applied benefit transfer (Johnston and Duke 2010). There are two main implications of using different non-market good or service changes for benefit transfer assessments. First, such differences may result in larger generalization errors than would occur if changes were identical across sites. Second, it means that the differences in the goods or services need to be reconciled, which is also a key step in applied benefit transfer (Smith and Pattanayak 2002; Smith et al. 2006; Van Houtven et al. 2007; Nelson and Kennedy 2009; Johnston and Rosenberger 2010). In their parallel choice experiments, Johnston and Duke (2010) used qualitative attributes with differing numbers of levels or definitions to better match conditions at each of their study sites. To reconcile these differences, they matched approximately similar levels across sites and if no match was possible then transfers were not completed. However, to our knowledge approaches to reconciling quantitative choice experiment attributes with differing levels have not been researched and our primary objective is to assess alternatives for doing so.

For choice experiments, reconciling quantitative attributes with different levels is potentially more flexible as they may be modeled as discrete or continuous variables. Modelling these attributes and levels as discrete variables requires the same approach to reconciliation as qualitative attributes. When the attributes are modeled as continuous variables the reconciliation approach depends on the variables' functional form. If these attributes are modeled linearly, which is the norm for benefit transfer (Johnston et al. 2015), then reconciliation is straightforward since marginal WTP is constant over all levels. However, preferences may be non-linear due to diminishing marginal utility meaning that marginal WTP varies by level. Thus using linear utility functions may increase generalization errors, especially for transfers where the quantities differ across sites. For transfers based on non-linear utility functions attribute reconciliation is not as simple since WTP is not constant. In this case economic theory and empirical research about respondent preferences point to a few approaches. Traditional economic theory posits that individual preferences for a particular option are independent of the larger set of options from which they can choose, which is the independence of irrelevant alternatives axiom (Tversky and Simonson 1993). For choice experiments, this means that choices are not influenced by the larger range of levels and that WTP values are 'absolute' (Luisetti et al. 2011). However, empirical studies provide contradicting evidence (e.g., Ariely et al. 2003; Hensher 2004). Recent research using choice experiments and split samples suggests that respondent preferences are 'relative' rather than 'absolute' meaning that choices are influenced by the range of levels included in the choice experiment, even for non-overlapping ranges (Luisetti et al. 2011; Kragt 2013).[53]

'Relative' and 'absolute' preferences suggest two alternative reconciliation approaches for transferring non-linearly modeled quantitative attributes with different levels. If preferences are 'relative', we would anticipate more valid and reliable transfers if the levels of the quantitative attributes from the sites are matched according to their

[53] The health risk literature on the sensitivity of willingness to pay (WTP) to the baseline characterization of the good or service is also informative. Gerking et al. (2017) summarize this literature, noting conflicting evidence that marginal WTP to reduce health risk is sensitive to baseline health risk (which would suggest that WTP is formed relative to the baseline). Certain studies find declining marginal WTP as baseline health risk rises and other studies find the opposite, while a few others find no sensitivity to the baseline. However, in their study Gerking et al. (2017) do find that such marginal WTP is sensitive to baseline health risk.

place in the range of levels and not their quantity (i.e., for an attribute with three levels we would match the lowest levels, the middle levels, and the highest levels regardless of their quantity). Alternatively, if preferences are ‘absolute’ transfer validity and reliability may be increased if the levels are matched according to their quantities. This approach suggests transferring the non-linear relationship relating WTP to the quantity of the attribute from the study site to the policy site (i.e., populating the relationship estimated from the study site with the levels from the policy site).These two approaches will yield the same results if the levels are identical across study and policy sites.

We seek to test three hypotheses related to attribute reconciliation. First, since Luisetti et al. (2011) and Kragt (2013) find that respondent preferences and values elicited via choice experiments are ‘relative’ we test whether benefit transfers based on matching levels according to their place in the range of levels (the ‘relative’ approach) are more valid and reliable than transfers based on matching level quantities (the ‘absolute’ approach). Second, since both approaches yield the same results when levels are identical we test whether the two approaches yield more similar results for transfers between sites with more similar levels than between sites with more dissimilar levels. Furthermore, we test a third hypothesis that transfers of WTP derived from non-linearly modeled attributes are more valid and reliable than transfers of WTP derived from linearly modeled attributes. To test these hypotheses we rely on choice experiments implemented in four case study watersheds located in the Canadian provinces of New Brunswick, Ontario, and British Columbia. These four case studies elicited WTP from local residents for improvements in water quality, increases in the extent of wildlife habitat, and changes in the income of local farm or forest producers.

5.2. Data and Method

Choice experiments are a stated preference technique that involves asking survey respondents to choose among alternative descriptions of a good or service in a hypothetical market (Hoyos 2010). The goods or services are characterized in terms of their key attributes and associated levels (for valuation research one of these attributes is monetary). Using a statistical design, multiple alternative descriptions are generated from these attributes and levels which are divided into several choice sets. For each set, respondents choose their favourite alternative and in doing so are forced to make trade-offs among the attributes and levels. Marginal utilities of each attribute or level are modeled from these choices, from which economic values are estimated.

5.2.1. Study Sites

We implemented our choice experiments in watersheds spanning Canada, including the Little River in Northwestern New Brunswick, the Humber and Credit Rivers in Southern Ontario, and the Salmon River in the Southern Interior of British Columbia (Figure 5.1 and Table 5.1). In terms of area, the Little River watershed is the smallest, while the Salmon River watershed is the largest (nearly 4 times larger than the Little). The area of the two Ontario watersheds falls near the middle of this range. Given their location in the Greater Toronto Area, the Humber and Credit watersheds have the largest populations, while the other two watersheds are much less populated and largely rural. In terms of land cover, the Little is majority forest or wetland, followed distantly by cropland, then shrubland or grassland, with a very small urban cover. The two Ontario watersheds have similar land cover, with cropland being the largest cover, followed by forest or wetland, urban area, and then shrubland or grassland. The Salmon River is majority forest or wetland, followed by shrubland or grassland, and cropland, with next to no urban or built up area inside its boundary (although there is a small city near the river's mouth).[54]

[54] Population data for each watershed is included in the supplementary material as Appendix D1.

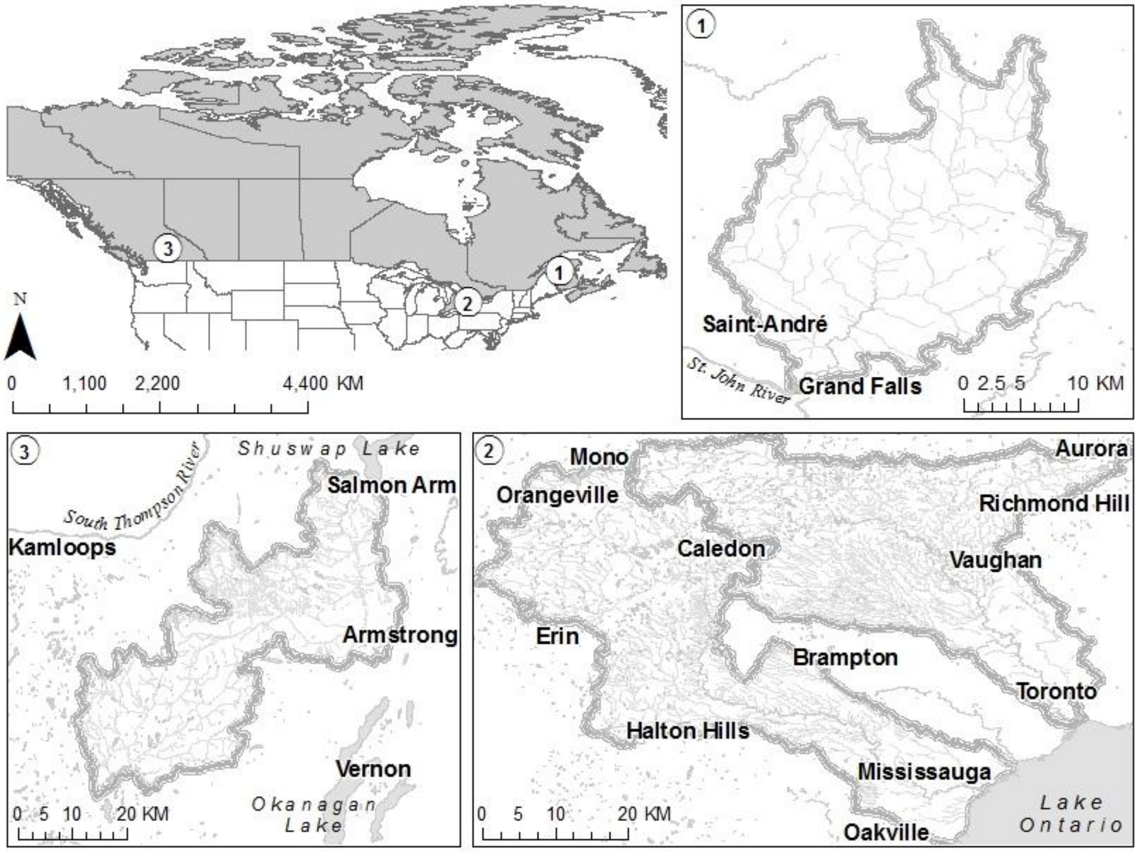

Figure 5.1: Study Sites
Clockwise: 1) Little River; 2) Humber River (east) and Credit River (west); and 3) Salmon River.

Table 5.1: Characteristics of the Little, Humber, Credit, and Salmon River Watersheds

Characteristic	Little	Humber	Credit	Salmon
Area (km^2)	390	911	1000	1500
Population[a]	6519	913,278	902,319	12,302
Land Cover[b]				
Forest or Wetland	78.9%	29.5%	34.4%	58.9%
Shrubland or Grassland	4.4%	1.2%	1.1%	37.7%
Cropland	16.7%	48.2%	43.3%	2.8%
Urban or Built-Up	0.1%	21.0%	20.6%	0%

[a] Population of the 2011 Census of Population dissemination areas intersecting with the watershed's boundaries (Statistics Canada 2012)

[b] Land cover based on an analysis of spatial data from the 2010 Land Cover Database of North America (Natural Resources Canada et al. 2010)

5.2.2. Data

The questionnaires were developed over a one year period. Local experts from the Eastern Canadian Soil and Water Conservation Centre (Little River), the Toronto and

Region Conservation Authority (Humber River), the Credit River Conservation Authority, and the Salmon River Watershed Roundtable participated at various stages of survey development. Initial survey drafts were written after consulting relevant literature and the final iteration of these drafts were reviewed by students in a survey design class at Simon Fraser University. Once suitable survey drafts were developed we held focus groups with residents of each watershed to get feedback. This process resulted in four nearly identical questionnaires that were divided into five sections with questions about: 1) respondents' relationship with the watershed; 2) the use and management of land in the watershed; 3) the current state, and concerns about the future state, of water quality, wildlife habitat, and farm / woodlot owner income (the non-cost attributes); 4) the choice experiment; and 5) socio-demographic characteristics.[55]

A concern when selecting the attributes for the choice experiment was that they be applicable to each watershed to enable an assessment of benefit transfer. We initially created a long list of potential environmental attributes and selected two indicators of water quality and wildlife habitat since there are issues with declining water and wildlife habitat quality in each watershed (McPhee et al. 1996; Kennedy and Wilson 2009; Chow et al. 2010; Zhu et al. 2011; Toronto and Region Conservation Authority 2013). The indicator used for our water quality attribute, the frequency of threats to water quality in 10 years, was based on part of the Canadian Council of Ministers of the Environment's Canadian Water Quality Guidelines for the Protection of Aquatic Life (Saffran et al. 2001). The same levels were used for each watershed (Table 5.2). The indicator used for our wildlife habitat attribute was defined as the proportion of the watershed protected as wildlife habitat in 10 years and the levels were tailored to each watershed. The status quo levels in the Ontario watersheds were informed by the watershed conservation authorities, while we approximated the proportion in the other watersheds using a geographic information system. We added a third attribute, representing the change in farm or woodlot owner income, since environmental stewardship programs required to improve water quality or increase wildlife habitat may negatively impact farming or forestry activities (e.g., taking land out of production). Finally, since our goal involves

[55] The survey was developed in English, though was translated into French by a bilingual employee of the Eastern Canadian Soil and Water Conservation Centre for use in the Little River watershed. The translation was reviewed by several people with knowledge of both languages.

estimating WTP we added a payment attribute, defined as an increase in annual income taxes over the next 10 years.[56]

Table 5.2: Attributes and levels

Attributes	Levels				Coding
	Little	Humber	Credit	Salmon	
Water Quality *Frequency of threats to water quality*	Often Sometimes Rarely	Often Sometimes Rarely	Often Sometimes Rarely	Often Sometimes Rarely	Effects
Wildlife Habitat *Percentage of private land in watershed that is protected for wildlife habitat*	5% 15% 25%	30% 40% 50%	25% 35% 45%	10% 20% 30%	Mean centred and scaled
Farm/Woodlot Income *Percentage change in farmer and woodlot owner income*	0%, -10% -20%	0% -10% -20%	0% -10% -20%	0% -10% -20%	Mean centred and scaled
Additional Income Tax *Increase in income tax paid each year*	$25, $50, $75, $100, $150, $200	$25, $50, $75, $100, $150, $200	$25, $50, $75, $100, $150, $200	$25, $50, $75, $100, $150, $200	Numeric

Since a full factorial design would be too large we used an orthogonal fractional factorial main effects design with 72 alternatives grouped into 36 choice sets (2 alternatives plus a status quo option per set).[57] The choice sets were then divided into six blocks so that respondents would only have to answer six choice sets (respondents were randomly assigned to a survey block). We examined the design for dominant alternatives and made slight modifications to reduce dominance with minimal consequences for orthogonality.

The choice experiment began with a description of how government funded programs can be used to maintain or improve environmental conditions in the watershed followed by instructions on how to complete the choice experiment tasks (see Appendix D2). A sample choice set was presented next, which provided respondents with definitions of each attribute as well as an illustration of how to answer. A cheap talk script, which may reduce hypothetical bias, was then presented to remind respondents about their budget constraint (Ladenburg and Olsen 2014). The six choice sets appeared next. Following each choice set, respondents were asked how certain they

[56] See Angus (2012) or Anderson (2013) for further details on attribute and level selection as well as survey design.

[57] Our design was developed by Dr. Don A. Anderson of StatDesign.

were about their answer using a textual scale with the following options: ‘very certain’; ‘certain’; and ‘uncertain’ (Lundhede et al. 2009). Finally, in an attempt to identify protest and strategic responses respondents were asked to identify the most important reason for their choices at the end of the choice experiment (Meyerhoff et al. 2014).

5.2.3. Data Collection

We mailed the questionnaires to a sample of households located in census subdivisions (CSD) that intersected with each watershed’s boundaries. Households were initially recruited by phone in June of 2011.[58] A total of 2156 households were called in the Little, 2334 in the Humber, 2201 in the Credit, and 2144 in the Salmon and around 800 households were recruited in each watershed (the household’s address was obtained and, in the case of the Little River, their language preference).[59] The surveys were administered concurrently during July and August of 2011. Households were initially sent a survey package containing a cover letter outlining the research and providing instructions, the questionnaire, as well as a postage paid return envelope. One week later a thank you/reminder post card was sent. A second survey package was sent a few weeks later to households who had not yet responded. As an incentive, respondents were entered into a draw for one of three $100 Visa Gift Cards (separate draws were held for each watershed).

We cleaned the data to remove missing observations on variables used in the modelling process. Furthermore, responses to each choice set deemed by the respondent as ‘uncertain’ were also removed from the analysis as were those from respondents who selected the status quo option for all choice sets and were also identified as protest responses (i.e., the most important reason for their choices being ‘do not trust the government’ or an open-ended response suggesting that the respondent did not state their actual preferences). Additional observations from those selecting the same non-status quo option for all choice sets were also removed.

[58] A tiny portion of the Credit watershed overlaps with the CSD of Toronto. Similarly, a small part of the Humber watershed overlaps with the CSD of Mississauga. However, households in the Toronto and Mississauga CSDs were not recruited for the Credit and Humber surveys, respectively. In addition, the number of households recruited for the Humber River survey from the CSD of Toronto was limited to no more than 50% of the total sample to ensure representation of the other regions of the watershed.

[59] The number of surveys successfully delivered in each watershed was 779 in the Little, 783 in the Humber, 791 in the Credit, and 783 in the Salmon.

5.2.4. Comparing Respondent Characteristics

A key condition of transfer validity and reliability is the similarity of the sites. Thus pairwise comparisons of demographic characteristics of respondents from each study site were conducted to ascertain site similarity in terms of gender, age, education, employment status, and income. We used Mann-Whitney tests for ordinal and continuous data since this test does not require normally distributed data, while Pearson's Chi^2 or Fisher's exact tests were used for categorical and binary data. We also compared sample characteristics to those of each watershed's population using binomial tests for binary data, Chi^2 tests for ordinal or categorical data, and t-tests for continuous data.

5.2.5. Econometric Modeling and Derivation of Willingness to Pay

We modeled our data using a random parameters logit (RPL) (see Appendix D3 for an overview). Among its advantages RPL models account for respondent heterogeneity, which has been shown to reduce transfer errors (Colombo et al. 2007a). We ran two types of models: 1) models with linear wildlife habitat and producer income; and 2) models with quadratic wildlife habitat and producer income. For each type we used Hole's (2007) 'mixlogit' command in Stata 12.1 to model our data using 2,000 Halton draws. All non-payment coefficients were treated as random and normally distributed, while the payment parameter was left as fixed to avoid unreasonably large WTP values. We specified the models so that all random parameters were correlated as this accounts for all sources of correlation and yields the correct estimation of the distribution of WTP (Hess and Train 2017). Thus our model output includes mean taste parameters as well as the lower-triangular elements of the Cholesky matrix. Following Johnston and Duke (2010), we also interacted select demographic variables with the alternative specific constant (ASC) and the payment parameters to incorporate observable respondent heterogeneity.[60] In the final models we retained interactions that were significant at the level of 10% for at least one watershed to ensure consistent interactions across models used in the transfer assessment. These final specifications

[60] The demographic variables interacted include: female; age in years; post-secondary education; employed full or part-time; and median household income or more. We initially ran these interactions for the quadratic specification only. The final specification for these interactions was then applied to the linear model specifications.

were then run for the linear and quadratic models five times each using different starting values and we selected the models yielding the lowest log-likelihood value for the benefit transfer assessment.

We derived marginal WTP and compensating surplus (CS) estimates following the simulation procedures outlined by Hu et al. (2005) and Czajkowski et al. (2015). This involved an initial round of ‘coefficient simulation’ to incorporate the uncertainty introduced by the sampling process and a second round of ‘parameter simulation’ that incorporates variation introduced by heterogeneous preferences. For the ‘coefficient simulation’ we took $\mathrm{R} = 2000$ draws from a multivariate normal distribution whose moments were defined by each model’s mean and lower-triangular Cholesky matrix parameters, and variance-covariance matrix. For each of these draws we generated a variance-covariance matrix for use in the second round from the simulated elements of the lower-triangular Cholesky matrix. For each of the R draws we conducted the ‘parameter simulation’ by taking $\mathrm{S} = 2000$ draws from a normal distribution characterized by the simulated random parameter and variance-covariance matrix. Marginal WTP and CS estimates are calculated for each of these draws following Hanemann (1984).This process yields R vectors of size S, or $\mathrm{R} \times \mathrm{S}$ estimates in total, representing the distribution of marginal WTP or CS. To determine the point estimate we adopted Johnston and Duke's (2008) mean of mean approach, which involves taking the mean of each of the R vectors of size S yielding a single vector of size R of which we also take the mean. The vectors of size R are also inputs into benefit transfer assessment.

5.2.6. Benefit Transfer Assessment

We examined transfer validity by testing the equality of models, using complete combinatorial tests and equivalence testing. The model parameters from the policy and study sites, β_{PS} and β_{SS} respectively, were compared using likelihood ratio tests that accounted for the scale parameter using the grid search procedure (Swait and Louviere 1993). The null hypothesis is that the models being compared are the same.

$$\mathrm{H}_0\colon \beta_{\mathrm{SS}} = \beta_{\mathrm{PS}} \tag{5.1a}$$

$$\mathrm{H}_1\colon \beta_{\mathrm{SS}} \neq \beta_{\mathrm{PS}} \tag{5.1b}$$

We examined the differences in WTP using two approaches. First we tested the null hypothesis that the values from the sites were equal using the complete combinatorial test (Poe et al. 2005). Unlike other tests, such as the t-test, these tests do not require normally distributed WTP.

$$\mathrm{H_0}: \mathrm{WTP_{SS}} = \mathrm{WTP_{PS}} \tag{5.2a}$$

$$\mathrm{H_1}: \mathrm{WTP_{SS}} \neq \mathrm{WTP_{PS}} \tag{5.2b}$$

However, testing whether values are equal may not make sense since the sites from which they are derived are inherently different. Therefore, we also used equivalence tests that do not assume that values are equal across different sites. Instead, they test whether the difference in the values is within a set of bounds known as the tolerance interval. The lower bound of the tolerance interval is $\phi_1 = \text{-}\delta(\overline{\mathrm{WTP}}_{\mathrm{PS}})$ and the upper bound is $\phi_2 = \delta(\overline{\mathrm{WTP}}_{\mathrm{PS}})$, where δ is the tolerance level in percent which is chosen by the researcher (Muthke and Holm-Mueller 2004; Johnston and Duke 2008). Relative to the complete combinatorial test, the hypotheses are reversed such that the null and alternative hypotheses are that the values are different and equivalent, respectively.

$$\mathrm{H_0}: \left(\mathrm{WTP_{SS}}\text{-}\mathrm{WTP_{PS}}\right) \leq \phi_1 \text{ or } \left(\mathrm{WTP_{SS}}\text{-}\mathrm{WTP_{PS}}\right) \geq \phi_2 \tag{5.3a}$$

$$\mathrm{H_1}: \phi_1 < \left(\mathrm{WTP_{SS}}\text{-}\mathrm{WTP_{PS}}\right) < \phi_2 \tag{5.3b}$$

In practice, this hypothesis is tested by assessing two sub hypotheses H_{0a} and H_{0b}. If they are both rejected then the WTP from the two sites is considered equivalent given the selected tolerance level.

$$\mathrm{H_{0a}}: \left(\mathrm{WTP_{SS}}\text{-}\mathrm{WTP_{PS}}\right) \leq \phi_1 \text{ or } \left(\mathrm{WTP_{SS}}\text{-}\mathrm{WTP_{PS}}\right)\text{-}\phi_1 \leq 0 \tag{5.4a}$$

$$\mathrm{H_{0b}}: \left(\mathrm{WTP_{SS}}\text{-}\mathrm{WTP_{PS}}\right) \geq \phi_2 \text{ or } \left(\mathrm{WTP_{SS}}\text{-}\mathrm{WTP_{PS}}\right)\text{-}\phi_2 \geq 0 \tag{5.4b}$$

We conducted this test using a variation of Johnston and Duke's (2008) two one-sided convolutions test developed by Czajkowski and Ščasný (2010). This approach trades the selection of a tolerance level for the selection of a significance level. We estimated the tolerance level at which the estimates of WTP are equivalent at the 95% level of significance.

Transfer reliability was tested via directional transfer errors calculated according to Equation 5.5. Since the denominator is the WTP at the policy site the resulting error will depend on the transfer's direction.

$$\text{Error (\%)} = \left|\frac{\text{WTP}_{\text{PS}}\text{-}\text{WTP}_{\text{SS}}}{\text{WTP}_{\text{PS}}}\right| \tag{5.5}$$

Note that the levels of the wildlife habitat attribute being compared for each transfer depend on the approach used to reconcile the differences in this attribute (see Table D2 in Appendix D4 for the level comparisons). In addition, the complete combinatorial tests conducted for the approach based on absolute preferences are directional since the quantities being compared for each test differ depending on which watersheds are treated as the policy and study sites. The 'relative' approach is not similarly affected.

5.3. Results

Depending on the watershed, survey response rates varied between 40% and 60%. After cleaning the data we only used between 30% and 45% of the surveys initially delivered (see Table D3 in Appendix D5 for the rates for each watershed). The rates are highest in the Salmon watershed, followed by the Little, Credit, and then Humber.

5.3.1. Respondent Characteristics

On the surface the demographic characteristics of our samples are similar to those of the population in each watershed (Table 5.3). However, relative to their respective populations our samples are generally significantly: more male (aside from the Salmon sample); older; more educated; more employed (although the Salmon watershed sample is less employed); and earning somewhat lower incomes (aside from the Salmon sample). Tests reveal that gender differs significantly across the Little River sample and the Humber and Salmon River samples which themselves differ significantly. The mean age for the Salmon sample is significantly older than the mean age observed for the other three watersheds, while the mean age of the Little sample is significantly older than the mean age of the Credit sample. Education differs significantly across all watersheds except the Little and Salmon. Employment differs significantly across all watersheds except the Credit and Humber. Finally, income differs significantly across all watersheds except the Credit and Humber. Overall, the Credit and Humber samples share relatively similar demographic characteristics. The Little and Salmon samples differ significantly from each other, and from the two Ontario samples, for most characteristics.

Table 5.3: Respondent Characteristics

Characteristic	Data Type	Little (1)	Humber (2)	Credit (3)	Salmon (4)	Testing 1 & 2	1 & 3	1 & 4	2 & 3	2 & 4	3 & 4
Gender (%)											
Female	Binary	37.1†††	45.6†	40.0†††	47.5	**		***			*
Male		62.9	54.4	60.0	52.5						
Age											
Mean (years)	Continuous	55.6†††	53.5†††	51.5†††	60.3†††		**	***		***	***
Education (%)											
Elementary	Ordinal	5.1†††	2.9†††	3.1†††	5.1†††	***	***		*	***	***
High school		41.5	18.8	21.9	38.1						
Diploma or bachelor's degree		48.0	59.4	62.7	45.5						
Graduate degree		5.5	18.8	12.3	11.3						
Employment status (%)											
Full-time	Categorical	54.5†	53.1†††	63.1††	33.6†††	**	*	***		***	***
Part-time		9.8	11.3	8.5	14.1						
Not working		3.6	9.6	5.8	5.6						
Retired		32.0	25.9	22.7	46.6						
Income (%)											
Less than $10,000	Ordinal	5.5†††	2.1†††	0.8†††	1.7	***	***	***		***	***
$10,000 to $29,999		19.6	6.7	5.4	17.8						
$30,000 to $49,999		30.5	17.6	11.9	24.0						
$50,000 to $74,999		24.4	19.2	23.5	23.2						
$75,000 to $99,999		12.0	18.8	21.9	18.1						
$100,000 or more		8.0	35.6	36.5	15.3						

[a] Certain employment status categories differ from those in the available population data. When comparing to population data via testing the 'Full-time' and 'Part-time' categories were collapsed into 'Employed' while the 'Not working' and 'Retired' sample categories were assumed to correspond with the 'Unemployed' and 'Not in labour force' population data categories.

[b] Certain income categories differ from those in the available population data. When comparing to population data via testing the '$50,000 to $74,999' and '$75,000 to $99,999' sample categories were assumed to correspond with the '$50,000 to $79,999' and '$80,000 to $99,999' population data categories.

†, ††, and ††† indicate that the characteristic differs from the population at the 90%, 95%, and 99% levels of significance, respectively

*, **, and *** indicate that the characteristic differs at the 90%, 95%, and 99% levels of significance, respectively

5.3.2. Econometric Models

We tested models with linear and quadratic specifications for the numerical attributes (Table 5.4). With McFadden pseudo R^2 values ranging from 0.27 to 0.36, depending on watershed and modeling approach, the models are of decent fit (Hensher et al. 2015). A likelihood ratio test reveals that the quadratic specification fits significantly better than the linear specification for the Little and Salmon models, and barely so for the Credit, while the specifications estimated for the Humber do not significantly differ $(\text{Little: } X^2_{(8)} = 38.3 \text{ with } p < 0.01; \text{Humber: } X^2_{(8)} = 2.5 \text{ with } p = 0.96; \text{Credit: } X^2_{(8)} = 13.5 \text{ with } p = 0.10; \text{and Salmon: } X^2_{(8)} = 37.7 \text{ with } p < 0.01)$. Similarly, the AIC and BIC suggest that the linear specification is more parsimonious for the Humber and Credit, while the AIC indicates that the quadratic specification is best for the other two watersheds though the BIC indicates otherwise.

Table 5.4: Linear and Quadratic Specifications of the Choice Models by Watershed

Variables	Little		Humber		Credit		Salmon	
	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Mean								
ASC	0.6996**	0.7802**	1.7017***	1.7883***	2.0342***	2.2994***	1.5830***	1.5667***
	(0.3118)	(0.3583)	(0.3513)	(0.3902)	(0.3312)	(0.3703)	(0.3042)	(0.3258)
Habitat	-0.0036	0.1269	0.2965**	0.3495**	0.1680	0.3596**	0.2599**	0.3240**
	(0.1230)	(0.1524)	(0.1327)	(0.1527)	(0.1238)	(0.1540)	(0.1194)	(0.1293)
Habitat^2		-0.6099***		-0.1639		-0.2280*		-0.6079***
		(0.1643)		(0.1429)		(0.1380)		(0.1140)
Water quality (WQ): sometimes	0.3521***	0.4648***	0.6705***	0.6756***	0.5229***	0.6168***	0.4442***	0.5399***
	(0.1092)	(0.1295)	(0.1376)	(0.1460)	(0.1288)	(0.1520)	(0.0998)	(0.1057)
Water quality (WQ): rarely	0.7415***	0.8454***	1.9347***	1.9669***	1.6375***	1.8328***	1.6040***	1.5956***
	(0.1566)	(0.1801)	(0.2121)	(0.2314)	(0.1814)	(0.2220)	(0.1629)	(0.1725)
Income	-0.1671	-0.2514**	-0.3383***	-0.3790***	-0.4160***	-0.5330***	-0.5753***	-0.6225***
	(0.1025)	(0.1169)	(0.1064)	(0.1198)	(0.1135)	(0.1357)	(0.0986)	(0.0974)
Income^2		-0.3108*		-0.5412***		-0.5165***		-0.3863***
		(0.1621)		(0.1610)		(0.1556)		(0.1238)
Tax	-0.0053	-0.0047	-0.0368***	-0.0389***	-0.0171***	-0.0212***	-0.0088	-0.0078
	(0.0063)	(0.0071)	(0.0068)	(0.0074)	(0.0062)	(0.0071)	(0.0057)	(0.0061)
ASC*Female	0.3404	0.4238	0.3266	0.4065	0.2426	0.2639	0.7559***	0.8352***
	(0.2771)	(0.3119)	(0.3820)	(0.4191)	(0.3206)	(0.3375)	(0.2876)	(0.3059)
ASC*Household income	0.6543**	0.7268**	0.6431	0.6104	0.1080	0.0754	0.2367	0.2205
	(0.3134)	(0.3489)	(0.4162)	(0.4848)	(0.3194)	(0.3336)	(0.2951)	(0.3112)
Tax*Age	-0.0001	-0.0001	0.0003***	0.0003***	0.0001	0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Tax*Female	-0.0085***	-0.0108***	0.0057**	0.0054*	-0.0022	-0.0017	-0.0033	-0.0041*
	(0.0029)	(0.0035)	(0.0028)	(0.0029)	(0.0030)	(0.0034)	(0.0022)	(0.0024)
Tax*Household income	-0.0019	-0.0030	0.0099***	0.0109***	-0.0016	-0.0028	0.0041*	0.0043*
	(0.0031)	(0.0036)	(0.0029)	(0.0031)	(0.0028)	(0.0033)	(0.0023)	(0.0025)
Elements of the Lower Triangular of the Cholesky Matrix								

Variables	Little		Humber		Credit		Salmon	
	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
ASC & ASC	1.9705***	2.1915***	-2.1792***	-2.3011***	2.2585***	2.4893***	0	-2.4648***
	(0.1942)	(0.2354)	(0.2602)	(0.2865)	(0.2478)	(0.2949)		(0.2363)
Habitat & ASC	0.7412***	0.9597***	-0.1709	-0.1051	0.5520***	0.6864***	0.7876***	-0.8242***
	(0.1931)	(0.2357)	(0.1935)	(0.2147)	(0.1902)	(0.2230)	(0.1687)	(0.1817)
$Habitat^2$ & ASC		-0.0757		-0.0423		-0.1515		-0.0231
		(0.2456)		(0.2113)		(0.2222)		(0.1739)
WQ: Sometimes & ASC	1.1694***	1.3630***	-0.5773**	-0.6268**	1.1487***	1.4032***	0.8198***	-0.8269***
	(0.2401)	(0.2851)	(0.2676)	(0.3013)	(0.2315)	(0.2832)	(0.2054)	(0.2106)
WQ: Rarely & ASC	0.1174	0.1703	0.0155	-0.0377	0.3240*	0.4709**	0.1910	-0.2208
	(0.1616)	(0.1937)	(0.1730)	(0.1928)	(0.1842)	(0.2155)	(0.1365)	(0.1416)
Income & ASC	-0.2079	-0.3105*	0.0598	0.1128	-0.0383	-0.1715	0.1678	-0.1703
	(0.1638)	(0.1826)	(0.1438)	(0.1631)	(0.1793)	(0.2039)	(0.1304)	(0.1307)
$Income^2$ & ASC		-0.3057		0.0247		-0.3113		0.0302
		(0.2391)		(0.2519)		(0.2302)		(0.1824)
Habitat & Habitat	0.7039***	-0.9045***	0.9567***	1.0436***	0.6152***	-0.8062***	0.7646***	0.8985***
	(0.1835)	(0.2181)	(0.1827)	(0.1965)	(0.1858)	(0.1926)	(0.1656)	(0.1790)
$Habitat^2$ & Habitat		0.1080		-0.1812		0.2647		-0.2780
		(0.3687)		(0.2483)		(0.2744)		(0.2222)
WQ: Sometimes & Habitat	-0.3037	0.1326	0.3866	0.5390*	-0.1805	0.0450	-0.4150	-0.3015
	(0.3251)	(0.3372)	(0.2715)	(0.2769)	(0.2958)	(0.2652)	(0.3000)	(0.2647)
WQ: Rarely & Habitat	-0.1982	0.1992	0.1607	0.1906	0.3726*	-0.2455	-0.0930	-0.0508
	(0.2354)	(0.2741)	(0.1749)	(0.1782)	(0.2201)	(0.2481)	(0.2028)	(0.1740)
Income & Habitat	-0.2698	0.2168	-0.0784	-0.0251	0.0470	-0.2148	-0.3004**	-0.1932
	(0.2280)	(0.2493)	(0.1624)	(0.1687)	(0.2425)	(0.2563)	(0.1451)	(0.1422)
$Income^2$ & Habitat		-0.3682		0.4246		0.0868		-0.1538
		(0.3065)		(0.2760)		(0.2872)		(0.2423)
$Habitat^2$ & $Habitat^2$		1.1201***		0.4054		-0.6122**		-0.2265
		(0.2689)		(0.3386)		(0.2681)		(0.2206)
WQ: Sometimes & $Habitat^2$		0.2551		-0.3220		-0.3186		-0.0765
		(0.3053)		(0.4306)		(0.2844)		(0.3484)
WQ: Rarely & $Habitat^2$		0.1450		0.1634		0.0706		-0.5740***
		(0.2831)		(0.2854)		(0.3042)		(0.1897)

Variables	Little		Humber		Credit		Salmon	
	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Income & Habitat^2		0.0800		-0.1903		0.5334*		0.0360
		(0.2564)		(0.2785)		(0.2758)		(0.1945)
Income^2 & Habitat^2		-0.0824		0.2335		-0.1828		0.2728
		(0.3503)		(0.3685)		(0.2837)		(0.2725)
WQ: Sometimes & WQ: Sometimes	-1.1168***	1.3475***	-1.4020***	-1.3837***	0.9115***	-0.9759***	-1.3964***	-1.4537***
	(0.2203)	(0.2429)	(0.2037)	(0.2422)	(0.2088)	(0.2016)	(0.1955)	(0.1880)
WQ: Rarely & WQ: Sometimes	-0.1208	0.0469	-0.5203***	-0.5303**	0.6031**	-0.3745	-0.2973*	-0.2423
	(0.2071)	(0.2189)	(0.1792)	(0.2176)	(0.2851)	(0.2597)	(0.1555)	(0.1873)
Income & WQ: Sometimes	0.1008	-0.0129	0.1386	0.2026	0.2176	-0.5728**	0.2221*	0.1180
	(0.1842)	(0.1931)	(0.1398)	(0.1673)	(0.2020)	(0.2352)	(0.1275)	(0.1318)
Income^2 & WQ: Sometimes		-0.1978		0.3523		0.4087*		0.2898
		(0.2730)		(0.2300)		(0.2152)		(0.1910)
WQ: Rarely & WQ: Rarely	-0.6621***	-0.7567***	-0.2694	-0.2890	0.5211	0.9403***	0.6198***	0.1505
	(0.1926)	(0.2753)	(0.3989)	(0.4471)	(0.4404)	(0.2333)	(0.1592)	(0.4300)
Income & WQ: Rarely	0.0384	0.2119	-0.0843	-0.1135	-0.4508	-0.4121	0.1672	0.1544
	(0.2224)	(0.3157)	(0.3076)	(0.3742)	(0.5207)	(0.2999)	(0.1534)	(0.3001)
Income^2 & WQ: Rarely		-0.3299		0.1135		0.0036		-0.1136
		(0.3956)		(0.5788)		(0.2578)		(0.4828)
Income & Income	0.5662***	0.5864***	0.1434	-0.1931	-0.6231	0.1879	-0.0851	-0.0964
	(0.1677)	(0.2148)	(0.3586)	(0.3934)	(0.4494)	(0.6809)	(0.3370)	(0.3749)
Income^2 & Income		-0.3470		0.1705		-0.0684		0.1764
		(0.3341)		(0.5842)		(0.4256)		(0.4962)
Income^2 & Income^2		0.1093		-0.0737		0.0126		0.0084
		(0.6167)		(0.6999)		(0.3469)		(0.5037)
Model Statistics								
Observations	4326		4011		4377		5898	
Log-likelihood	-1146.33	-1127.20	-895.33	-894.07	-1015.88	-1009.13	-1410.76	-1391.90
AIC (BIC)	2358.67	2336.39	1856.66	1870.13	2097.75	2100.27	2887.52	2865.81
	(2568.96)	(2597.66)	(2064.46)	(2128.30)	(2308.43)	(2362.02)	(3108.03)	(3139.79)
McFadden's R^2	0.27	0.29	0.36	0.36	0.33	0.34	0.32	0.33

[a] Standard errors appear in brackets below the corresponding coefficient.

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

For the linear specification, the mean habitat parameter is only significant for the Humber and Salmon models and positive in both cases, suggesting that respondents in these watersheds generally prefer higher levels of habitat. For the quadratic specification, the linear and quadratic terms in all models are positive and negative, respectively. However, the linear term is insignificant for the Little model as is the Humber model's quadratic term. These relationships suggest that respondents in the Little and Salmon generally prefer the middle level of habitat, followed by the highest and lowest levels, while those in the Ontario watersheds prefer the highest level, followed by the middle and lowest levels. All quadratic relationships exhibit diminishing marginal utility of habitat, though respondents in the Little and Salmon appear much more sensitive to changes than those in the Ontario watersheds. The mean ASCs are positive and significant for all models. Respondents in all watersheds held similar preferences for changes in water quality regardless of model, with the most preferred level being 'rarely threatened', followed by 'sometimes threatened', and then distantly 'often threatened'. Preferences for changes in producer income arising from the linear model indicate that respondents generally dislike reductions in such income, though this relationship is insignificant for the Little model. The relationships estimated as part of the quadratic model reveal that respondents in the Little and Humber watersheds find modest losses in producer income of 10% acceptable relative to no change though strongly dislike larger 20% declines. Those in the Credit and Salmon watershed prefer no loss in producer income, followed by a decline of 10%, and then a decline of 20%. The tax parameters are generally negative, indicating that respondents dislike paying more, though in the case of the Little and Salmon they are insignificant (likely due to the interactions).

In terms of significant demographic interactions, findings are fairly consistent across the linear and quadratic specifications. For the Little models, respondents with higher incomes are more likely to choose a non-status quo option and female respondents have a higher marginal utility of income. The marginal utility of income is lower for wealthier, older, and female respondents for the Humber model, while all interactions are insignificant for the Credit models. For the Salmon models, female respondents are more likely to choose a non-status quo alternative and have a higher marginal utility of income, the latter for the quadratic model only, while higher income respondents have a lower marginal utility of income. The standard deviation parameters calculated from the lower-triangular of the Cholesky matrix suggest that respondents in the Little, Credit, and Salmon watersheds have heterogeneous preferences for all attributes while those in the Humber hold such preferences for most attributes, regardless of model (see Appendix D6).

Marginal WTP and CS Estimates

Marginal WTP estimated for changes in the ASC variable and water quality attribute are fairly similar across model specifications, though the quadratic model yields somewhat smaller estimates for all watersheds except the Humber (Figure 5.2). The marginal values estimated for a change in the ASC variable are fairly similar for the Humber, Credit, and Salmon watersheds, while the values elicited for the Little watershed are much lower.[61] For changes in water quality, respondents in the Humber are willing to pay the most, followed by those in the Salmon or Credit, and more distantly the Little. The marginal values estimated for the ASC and water quality are notably larger than those estimated for the wildlife habitat and income attributes. The marginal WTP for changes in wildlife habitat estimated from the linear model are all positive and largest for the Humber or Salmon watersheds, followed by the Credit, and then the Little, while the values estimated for changes in producer income are all negative with the largest value observed for the Little, followed by the Humber, Credit, and then Salmon. Diminishing marginal WTP is observed for changes in wildlife habitat and producer income estimated from the quadratic model. Marginal WTP estimated for the Little and Salmon watersheds is more sensitive to changes in wildlife habitat relative to the Ontario watersheds, while marginal WTP estimated for the Little appears least sensitive to declines in producer income, followed by the Salmon, Credit, and then Humber.

[61] Though not an attribute, we include the ASC in our analysis of transfers of marginal WTP since it is a component of CS.

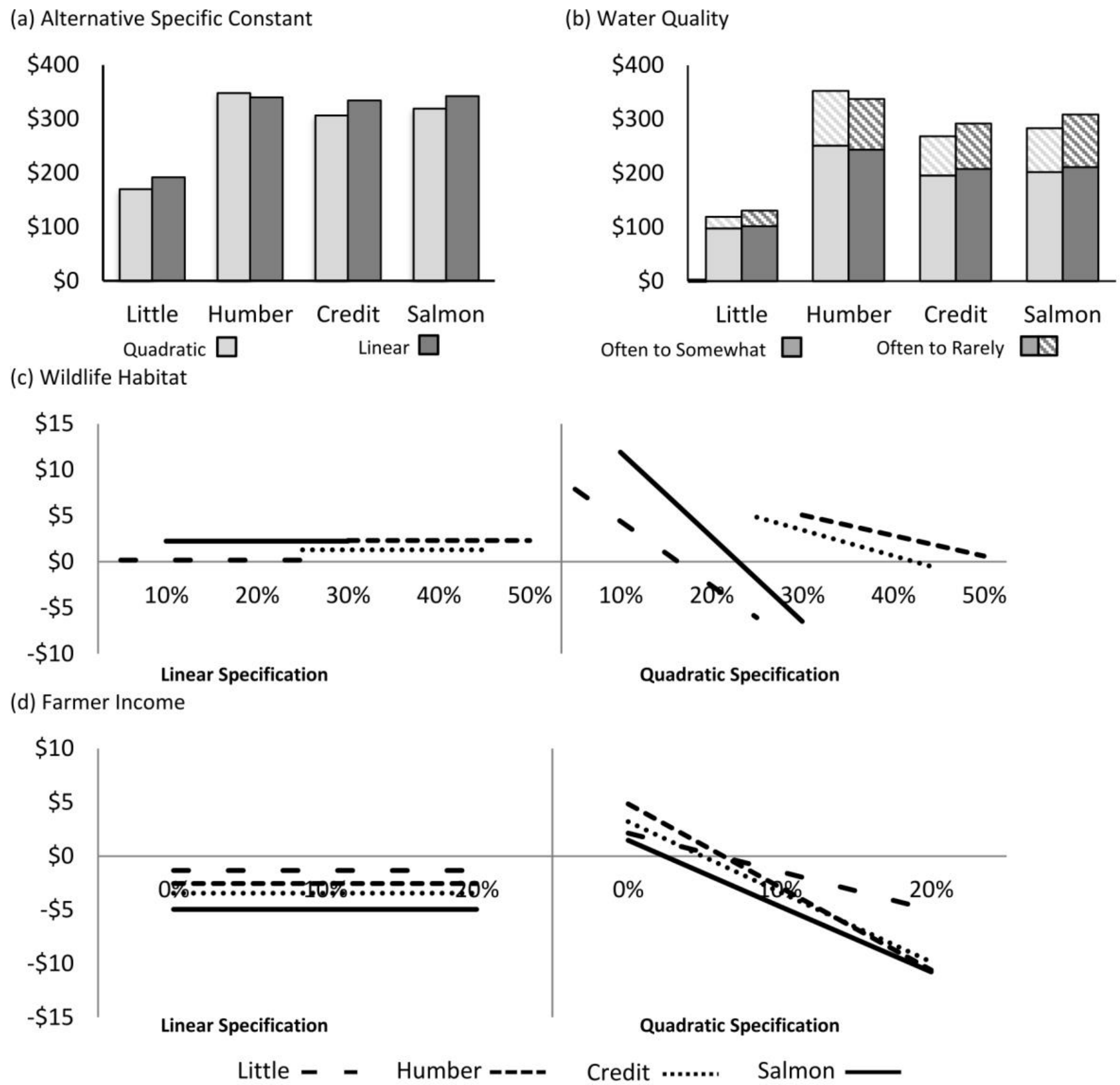

Figure 5.2: Marginal Willingness to Pay per Year Derived for the Four Watersheds (2011 CAD)

For changes in water quality in panel (b): marginal WTP for improvements from ‘often’ to ‘somewhat threatened’ are represented by the solid shaded portion of the bar, while marginal WTP for improvements from ‘often’ to ‘rarely threatened’ are represented by the combined solid shaded and diagonal line shaded portions; and WTP from the linear and quadratic models are represented by the light and dark grey bars, respectively.

Compensating surplus estimated from the models depends on the approach used to reconcile wildlife habitat and the model specification (Figure 5.3). The values are quite variable, and can be large in magnitude, with those estimated for the ‘relative’ approach ranging from $141.24 to $766.61 and the ‘absolute’ approach ranging from -$210.73 to $766.61 (the maximum values are the same since the CS estimates calculated for the ‘relative’ approach are a subset of those calculated for the ‘absolute’ approach). The CS estimates resulting from the linear and quadratic models are somewhat similar though there are differences (e.g., for the ‘absolute’ approach the CS values for each watershed diverge more for the quadratic models relative to the linear model). The Little watershed is clearly an outlier as the CS estimates for this watershed are much lower than those values estimated for the other watersheds. The Salmon and Humber watersheds appear to have similar CS values, though they are more divergent for the quadratic model when reconciled via the ‘absolute’ approach, and these estimates are not terribly different from those estimated for the Credit.

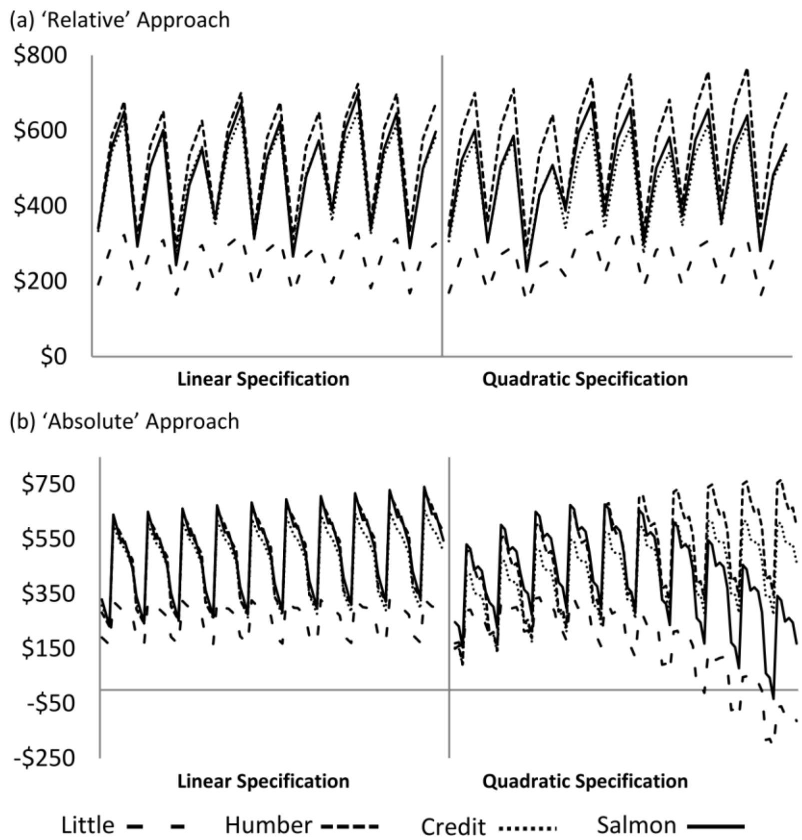

Figure 5.3: Compensating Surplus per Year Estimates (2011 CAD)

5.3.3. Testing Transfer Validity and Reliability

Testing the Similarity of Models

For both the linear and quadratic specifications the likelihood ratio tests used to compare the model parameters across watersheds reject the null hypothesis that the models are equal at the 99% level of significance (Table 5.5). Thus, models differ by watershed.

Table 5.5: Likelihood Ratio Test Results for Model Comparisons

Comparison	Pooled Log Likelihood		Relative Scale		Likelihood Ratio p-value	
	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Little & Humber	-2108.88	-2092.87	0.60	0.60	<0.01***	<0.01***
Little & Credit	-2212.56	-2196.30	0.65	0.65	<0.01***	<0.01***
Little & Salmon	-2611.37	-2577.08	0.65	0.60	<0.01***	<0.01***
Humber & Credit	-1960.61	-1939.79	0.95	0.90	<0.01***	<0.01***
Humber & Salmon	-2377.03	-2357.26	1.25	1.20	<0.01***	<0.01***
Credit & Salmon	-2501.84	-2477.99	1.15	1.05	<0.01***	<0.01***

*, **, and *** indicate that the models differ from each other at the 90%, 95%, and 99% levels of significance, respectively

The Validity and Reliability of Transfers of Wildlife Habitat and Producer Income Marginal WTP

For wildlife habitat the transfer yielding the lowest errors or tolerance levels depends on transfer direction, model, level in the case of quadratic model, and reconciliation approach (Table 5.6). For the linear model, transfers of marginal WTP for changes in habitat involving the Little yield the highest errors and tolerance levels especially when this site is the policy site, while those between the Humber and Salmon result in the lowest errors and tolerance levels. For the quadratic model, averaging across reconciliation approaches and transfer direction reveals that the errors are also largest for transfers involving the Little, while the lowest errors are generally for transfers between the Humber and Credit or Salmon depending on whether the average is the mean or median. The order differs somewhat for tolerance levels. Average tolerance levels are lowest for transfers between the Humber and Credit and highest for transfers between the Little and Humber. The ‘relative’ approach results in the lowest errors and tolerance levels overall, while the ‘absolute’ approach yields the largest errors overall and using linear habitat results in the largest tolerance levels. However, the best approach depends on the transfer. For instance, the linear approach yields the lowest errors and tolerance levels for transfers between the Humber and Salmon, while the ‘relative’ approach yields lowest errors and tolerance levels for transfers between the Little and Salmon.

Table 5.6: Errors, Tolerance Levels, and Complete Combinatorial p-values for Transfers of Wildlife Habitat Marginal WTP[a]

Transfer and Policy Site	Linear Habitat	Quadratic Habitat					
		'Relative'			'Absolute'		
		L1	L2	L3	L1	L2	L3
Little & Humber							
Little	1109 [2273]	36 [108]	211 [475]	110 [190]	35 [118]	822 [172]	202 [326]
Humber	92 [188]	56 [168]	68 [153]	1098 [1893]	288 [416]	682 [969]	3967 [5874]
CC p-value	0.06*	0.21	0.10*	0.01**	0.36 0.00***	0.10* 0.00***	0.00*** 0.00***
Little & Credit							
Little	576 [1684]	39 [104]	125 [364]	88 [163]	32 [314]	735 [184]	180 [158]
Credit	85 [250]	63 [170]	56 [162]	731 [1354]	225 [149]	735 [199]	2644 [308]
CC p-value	0.20	0.16	0.20	0.03**	0.34 <0.01***	0.04** <0.01***	<0.01*** <0.01***
Little & Salmon							
Little	1085 [2243]	51 [115]	198 [433]	7 [81]	109 [189]	700 [739]	69 [388]
Salmon	92 [190]	34 [76]	66 [146]	6 [76]	63 [326]	195 [1053]	48 [4007]
CC p-value	0.06*	0.10*	0.09*	0.44	0.01*** <0.01***	<0.01*** <0.01***	0.04** 0.18
Humber & Credit							
Humber	44 [145]	5 [115]	28 [115]	220 [976]	32 [221]	77 [167]	449 [152]
Credit	79 [258]	5 [120]	38 [159]	183 [813]	28 [98]	93 [290]	336 [136]
CC p-value	0.23	0.47	0.30	0.32	0.29 0.37	0.10* 0.17	0.21 0.14
Humber & Salmon							
Humber	2 [107]	135 [243]	4 [92]	1163 [1904]	227 [118]	651 [451]	4182 [259]
Salmon	2 [109]	57 [104]	5 [96]	109 [180]	20 [88]	169 [125]	178 [429]
CC p-value	0.49	0.02**	0.47	0.01***	<0.01*** 0.37	<0.01*** 0.16	<0.01*** <0.01***
Credit & Salmon							
Credit	75 [254]	146 [247]	32 [141]	786 [1360]	139 [759]	638 [181]	2672 [144]
Salmon	43 [145]	59 [101]	24 [107]	89 [154]	24 [153]	129 [161]	153 [189]

Transfer and Policy Site	Linear Habitat	Quadratic Habitat					
		‘Relative’			‘Absolute’		
		L1	L2	L3	L1	L2	L3
CC p-value	0.24	0.01***	0.31	0.01**	<0.01*** 0.29	<0.01*** 0.13	<0.01*** <0.01***
Overall							
Error[b]	274 (82)		170 (61)			609 (188)	
Tolerance[b]	654 (220)		368 (157)			556 (194)	
CC Different Pairs[c]	0%		33%			61%	

[a] Errors [tolerance levels in square brackets]

[b] Mean (median in round brackets)

[c] Percentage of CC tests deeming a pair of estimates different at the 95% level of significance

*, **, and *** indicate that the values differ from each other at the 90%, 95%, and 99% levels of significance, respectively

In terms of the complete combinatorial test, the marginal WTP for changes in habitat resulting from the linear model differ significantly for transfers between the Little and the Humber or Salmon (Table 5.6). For quadratic habitat, results differ by reconciliation approach and level. In terms of the 'relative' approach, we observed no significant differences for transfers between the Humber and Credit watersheds, only a single such difference for transfers between the Little and Credit, and two significant differences for the remaining transfers. The complete combinatorial tests for the 'absolute' approach are directional, though the results are similar to the other approaches in that the fewest statistically different pairs occur for transfers between the Humber and Credit. Transfers between the Salmon and Humber or Credit yield the second fewest number of significantly different pairs followed by transfers involving the Little. Overall none of the pairs differ at the 95% level of significance for linear habitat, while a third of the pairs differ at this significance level for the 'relative' approach, and just over 60% for the 'absolute' approach.

Errors for transfers of wildlife habitat based on the quadratic model clearly depend on the level and approach. For example, transfers between the Humber and Salmon for level 2 of the 'relative' approach yield errors around 5% while transfers of the other levels of habitat yield substantially higher errors. We observe similar variation for transfers based on the 'absolute' approach. The large transfer errors may result from the interplay between the equation used to calculate errors and the non-constant WTP estimated for these attributes. The denominator of the transfer error equation varies by wildlife habitat level and as the denominator approaches zero the errors increase rapidly (as illustrated in Appendix D7, the point at which the denominator is zero is an asymptote). When marginal WTP at the policy site is zero, the denominator is zero, which occurs for wildlife habitat around 16% for the Little, 53% for the Humber, 42% for the Credit, and 23% for the Salmon (e.g., when the Humber is the policy site and wildlife habitat is at 50% the errors are 1000% and 4000% for the 'relative' and 'absolute' approaches, respectively). If the error equation's numerator is small, which we observe for transfers between the Humber and Credit, errors do not explode even when the denominator is close to zero. Furthermore, we are more likely to observe extremely large errors when the slope of the policy site's marginal WTP function is flatter since the denominator is near zero over a wider range of levels (e.g., Humber or Credit). We also observed relatively large tolerance levels for the same transfers as the large errors and similar reasoning applies. When marginal WTP values at the policy site approach zero the tolerance levels must become large, increasing the size of the tolerance interval to the point where the test deems a pair of estimates equivalent at the 95% level of significance.

The validity and reliability of transfers of marginal WTP for changes in producer income also vary by several factors (Table 5.7). For transfers based on the linear model, the lowest errors result from transfers between the Credit and Humber or Salmon, while the largest errors result from transfers between the Little and Humber. The corresponding tolerance levels were lowest for transfers between the Credit and Salmon and largest for transfers involving the Little. For quadratic producer income the results differ by level. However, averaging across levels reveals that transfers between the adjacent Humber and Credit yield the lowest errors overall and transfers between the distant Little and Salmon result in the largest errors.[62] On average, the corresponding tolerance levels were lowest for transfers between the Credit and Humber or Salmon and largest for transfers between the Little and Humber or Salmon. Results of the complete combinatorial tests show that marginal WTP resulting from the linear model specification differs significantly for transfers between the Little and Credit or Salmon as well as between the Humber and Salmon. For the quadratic specification, no significant differences were observed for transfers between the Credit and Humber or Salmon, a single significant difference for transfers between the Humber and Little or Salmon, and two such differences for the other transfers. Furthermore, we observe no significantly different pairs of estimates at the status quo level and three for each of the other levels. Overall, transfers of marginal WTP for changes in producer income based on the quadratic specification yield lower average errors than transfers based on the linear specification. However, the opposite holds for tolerance levels. In addition, the linear model results in nearly twice the share of pairs that differ at the 95% level of significance than the quadratic model.

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[62] Transfers of quadratic marginal WTP for changes in producer income are subject to the issue with very large errors and tolerance levels that we described earlier for wildlife habitat. For producer income, the asymptotes occur around the -6% level for the Little, -5% for the Humber, and -2% for both the Credit and Salmon.

Table 5.7: Errors, Tolerance Levels, and Complete Combinatorial p-values for Transfers of Marginal WTP for Changes in Producer Income[a]

Transfer and Policy Site	Linear Producer Income	Quadratic Producer Income 0%	-10%	-20%
Little & Humber				
Little	90 [221]	126 [384]	102 [239]	112 [223]
Humber	48 [116]	56 [170]	50 [119]	53 [106]
CC p-value	0.13	0.21	0.11	0.05**
Little & Credit				
Little	155 [295]	49 [277]	133 [260]	97 [191]
Credit	61 [116]	33 [186]	57 [112]	49 [97]
CC p-value	0.03**	0.36	0.04**	0.04**
Little & Salmon				
Little	267 [403]	32 [257]	225 [342]	115 [211]
Salmon	73 [110]	47 [377]	69 [105]	54 [99]
CC p-value	<0.01***	0.41	<0.01***	0.02**
Humber & Credit				
Humber	34 [110]	34 [149]	15 [89]	7 [61]
Credit	25 [82]	52 [226]	13 [77]	8 [66]
CC p-value	0.23	0.31	0.36	0.41
Humber & Salmon				
Humber	93 [167]	70 [185]	61 [131]	2 [56]
Salmon	48 [87]	232 [611]	38 [81]	1 [56]
CC p-value	0.02**	0.16	0.07*	0.48
Credit & Salmon				
Credit	44 [103]	54 [208]	40 [96]	9 [60]
Salmon	30 [72]	118 [454]	28 [69]	9 [55]
CC p-value	0.11	0.28	0.12	0.38
Overall				
Error[b]	81 (54)		63 (51)	
Tolerance[b]	157 (113)		180 (140)	
CC Different Pairs[c]	50%		28%	

[a] Errors [tolerance levels in square brackets]

[b] Mean (median in round brackets)

[c] Percentage of CC tests deeming a pair of estimates different at the 95% level of significance

*, **, and *** indicate that the values differ from each other at the 90%, 95%, and 99% levels of significance, respectively

Examining Transfer Errors and Testing the Similarity of CS Estimates

Transfers of compensating surplus (CS) are also influenced by site treatment and transfer direction, habitat reconciliation approach, as well as model specification (Table 5.8). Although the ‘relative’ and ‘absolute’ reconciliation approaches can be applied to transfers of CS estimated from the linear model these approaches yield identical results for this specification since the change in habitat is the same and marginal WTP does not vary by habitat level. In addition, all approaches yield the same results when habitat is at the status quo level since there is no change in habitat (though the other attributes do change). For both the linear and quadratic specifications, and regardless of reconciliation approach, transfer errors and tolerance levels are highest for transfers involving the Little watershed. The lowest mean of the errors and tolerance levels are observed for transfers between the Credit and Salmon. Transfers involving the Little yield the largest share of pairs of estimates deemed different at the 95% level of significance, while none of the pairs of estimates for transfers between the Humber and Credit were deemed significantly different and only a small share for transfers between the other watersheds (and only for the ‘absolute’ approach). The effect of transfer direction is most pronounced for transfers involving the Little with those to this watershed yielding much larger errors and tolerance levels on average than in the other direction. However, errors and tolerance levels also clearly differ by direction for transfers between the Salmon and Humber or Credit in the case of the ‘absolute’ reconciliation approach.

Table 5.8: Mean of the Errors and Tolerance Levels, as well as Statistically Different Pairs for Transfers of CS Estimates by Model and Habitat Treatment[a]

Transfer and Policy Site	Linear	Quadratic	
		'Relative'	'Absolute'
Little & Humber			
Little	103 [159]	120 [179]	142 [219]
Humber	51 [78]	54 [82]	87 [119]
CC Different Pairs[b]	100%	100%	100%
Little & Credit			
Little	84 [139]	80 [135]	103 [167]
Credit	45 [76]	44 [75]	76 [110]
CC Different Pairs[b]	93%	93%	96%
Little & Salmon			
Little	87 [141]	89 [143]	108 [163]
Salmon	46 [76]	47 [76]	54 [83]
CC Different Pairs[b]	89%	89%	96%
Humber & Credit			
Humber	9 [39]	18 [47]	20 [50]
Credit	11 [43]	22 [57]	24 [60]
CC Different Pairs[b]	0%	0%	0%
Humber & Salmon			
Humber	8 [38]	14 [43]	48 [79]
Salmon	9 [42]	16 [50]	26 [65]
CC Different Pairs[b]	0%	0%	33%
Credit & Salmon			
Credit	3 [36]	6 [38]	27 [61]
Salmon	3 [35]	5 [36]	6 [41]
CC Different Pairs[b]	0%	0%	17%
Overall			
Errors[c]	38 (25)	43 (30)	60 (50)
Tolerance[c]	75 (69)	80 (70)	101 (81)
CC Different Pairs[b]	47%	47%	57%

[a] Mean errors [mean tolerance levels in square brackets]

[b] Percentage of CC tests deeming a pair of estimates different at the 95% level of significance

[c] Mean (median in brackets)

In terms of the two reconciliation approaches based on the quadratic model, the 'relative' approach yields lower average errors and tolerance levels than the 'absolute' approach for all transfers. The 'relative' approach also yields an equal or lower share of estimate pairs deemed different at the 95% level of significance for each transfer. Furthermore, the mean of the errors and tolerance levels are appreciably higher for all transfers based on the 'absolute' approach other than those between the Humber and Credit and to a lesser extent the Little and Salmon (the two watershed pairs with the most similar wildlife habitat levels). Comparing the same compensating surplus specification reveals that the ‘relative’ approach yields the lowest errors and tolerance levels in nearly all cases (see Appendix D8, Table D11).

Overall, transfers based on the linear model specification yield lower average errors and tolerance levels than transfers based on the quadratic specification, although the average errors and tolerance levels resulting from the ‘relative’ approach are close. Similarly, the proportion of estimate pairs from the linear model deemed different at 95% significance is equal to the share estimated for the ‘relative’ approach and lower than that estimated for the ‘absolute’ approach. Comparing transfers for the same CS estimate resulting from the linear and ’relative’ approaches reveals that the linear model yields the lowest errors and tolerance levels in the vast majority of cases (see Appendix D8, Table D12). When compared to the ‘absolute’ approach, transfers based on the linear model yield the lowest errors and tolerance levels in nearly all cases.

5.4. Discussion

We evaluated the validity and reliability of transferring WTP for changes in ecosystem services across four Canadian watershed case study sites using a convergent validity approach. Our focus was to examine different approaches to reconciling a quantitative attribute with levels that differ by case study site. Overall, the directional transfer errors we observed for transfers of marginal WTP ranged from 1% to 4182% with a mean of 161% and median of 54%, while the corresponding tolerance levels ranged from 30% to 5874% with a mean of 298% and median of 136%. For compensating surplus, the directional transfer errors ranged from 0% to 191% with a mean of 43% and median of 40%, while the associated tolerance levels ranged from 27% to 327% with a mean and median of 81% and 72%, respectively. Furthermore, the null hypothesis of equal model parameters was rejected in all cases, which is not surprising given that correlated random coefficients require a large number of model parameters making it likely that there are differences (Colombo et al. 2007b). The null hypothesis of equal values was rejected for marginal WTP 43% of the time and for compensating surplus 49% of the time (at the 95% level of significance). The errors and test results are comparable to those resulting from previous research outlined by Kaul et al. (2013) and Rosenberger (2015) in their comprehensive reviews of the literature.

We now review the evidence pertaining to each of the hypotheses outlined in the introduction. The first hypothesis we set out to assess was that transfers based on relative preferences are more valid and reliable than transfers based on absolute preferences, given that empirical research suggests that respondents to choice experiments have relative preferences (e.g., Luisetti et al. (2011)). We rely on transfers of wildlife habitat for this assessment as the levels of this attribute differed across the case study sites. On average, the 'relative' approach yields the lowest transfer errors and tolerance levels for transfers of marginal WTP and CS estimates. Furthermore, when compared directly the 'relative' approach yielded lower errors and tolerance levels than the 'absolute' approach for nearly every transfer. Similarly, the proportion of pairs of marginal WTP or CS estimates deemed significantly different by the complete combinatorial test is lowest for the 'relative' approach. In sum, evidence from our study suggests that transfers based on 'relative' preferences are more valid and reliable than those based on 'absolute' preferences.

The 'absolute' approach to reconciliation involves comparing certain values of wildlife habitat outside of the range from which they were estimated, which may reduce this approach's validity and reliability. For instance, the relationship for wildlife habitat estimated for the Humber, Credit, and Salmon are all used for values outside of the range at which they were estimated when transferred to the Little. In some cases, such as at the 5% level, this entails a loss from the status quo levels at these study sites (10%, 25%, and 30%, respectively, in the Salmon, Credit, and Humber). Prospect theory suggests that gains and losses are valued asymmetrically (Kahneman and Tversky 1979). Given this asymmetry, it is unlikely that the relationship estimated for a gain in wildlife habitat could be extended to a situation that is actually a loss without increasing generalization errors.

The second hypothesis we set out to examine was that the approach to reconciling quantitative attributes with differing levels matters less when the levels are closer together since the two approaches will provide identical results if the levels are the same. The Credit and Humber as well as the Little and Salmon have similar levels relative to the other case study site pairs. For these two pairs, the levels for the habitat attribute differ by 5 percentage points, while the levels for the remaining pairs differ by at least 15 points. Thus we expect less difference in errors and tolerance levels for transfers between these watershed pairs relative to the other pairs. We do observe this to some extent for marginal WTP since the errors vary less for transfers between the Credit and Humber, though not the tolerance levels, while this variation is higher for transfers between the Little and Salmon than the other transfers (Table 5.9). However, for CS the evidence suggests that transfers between sites in these two pairs of watersheds are more valid and reliable than transfers among the other pairs. Furthermore, isolating the wildlife habitat component of CS reveals that the approaches are more similar for transfers between the two pairs of watersheds when habitat is the only attribute that changes. The transfers of marginal estimates are affected by asymptotes, which obfuscates the comparison of the validity and reliability of the two reconciliation approaches for these values since the transfers are not equally affected by asymptotes. CS and its habitat component are not similarly affected. Therefore, there is evidence that the approach to attribute reconciliation matters less when the levels are closer together, although this finding is not as clear for transfers of marginal WTP.

Table 5.9: Average Percent Difference between the 'Relative' and 'Absolute' Reconciliation Approaches

Watershed Pair	Habitat Marginal WTP		CS		Habitat Component of CS	
	Error	Tolerance	Error	Tolerance	Error	Tolerance
Little & Humber	193 (174)	123 (112)	31 (25)	27 (27)	789 (534)	237 (230)
Little & Credit	228 (166)	76 (47)	39 (36)	28 (29)	462 (472)	208 (193)
Little & Salmon	221 (147)	588 (216)	16 (15)	10 (10)	122 (120)	69 (71)
Humber & Credit	158 (111)	133 (67)	12 (11)	5 (6)	134 (132)	39 (44)
Humber & Salmon	1704 (145)	136 (88)	149 (67)	43 (38)	2410 (1030)	212 (175)
Credit & Salmon	262 (129)	122 (42)	654 (93)	29 (15)	490 (432)	124 (100)

[a] We calculated the percent difference in errors or tolerance levels between the 'relative' and 'absolute' approaches by: 1) taking the percent difference for the same marginal level or CS specification between the approaches, yielding two percentages for each level or specification since the value depends on the denominator; 2) taking the average of these directional values; and 3) taking the mean or median of all resulting values for each pair of watersheds.

[b] Mean of percent changes with median in brackets.

For our third hypothesis we investigated whether transfers of WTP derived from models with non-linear attributes are more valid and reliable than transfers of WTP derived from models with linear attributes. We derived WTP from two model specifications, one treating quantitative attributes as linear and the other quadratic, and then conducted parallel transfer assessments for marginal WTP and CS. For marginal WTP, results differ by attribute. In the case of wildlife habitat, errors and tolerance levels suggest that transfers based on the linear model are less valid and reliable than those based on the quadratic 'relative' approach though more valid than the 'absolute' approach. However, complete combinatorial test results suggest that transfers based on the linear model are more valid than either of those based on the quadratic model. The divergent conclusion resulting from the complete combinatorial test may arise from its use of a traditional hypothesis. In this case, more variable WTP estimates are more likely to be deemed equal and thus transfers more valid, while the opposite is true for equivalence tests (Kristofersson and Navrud 2005; Johnston and Duke 2008). Thus, our results are sensible if estimates resulting from the linear model are less efficient than those generated from the quadratic model for the ‘relative’ approach. For producer income, errors and tolerance levels indicate that transfers based on the linear model are less reliable though more valid than transfers based on the quadratic specification, although the complete combinatorial tests suggest that transfers based on the linear model are less valid. For CS, errors and tolerance levels suggest that transfers based on the linear specification are more valid and reliable than those based on either of the quadratic approaches. However, the complete combinatorial test results indicate that transfers based on the linear model are similarly valid to those based on the quadratic model’s ‘relative’ approach and more valid than transfers based on the ‘absolute’ approach.

One reason that transfers of CS based on the linear model are more valid and reliable is that CS incorporates values of the ASC variable and water quality attribute. As such, the validity and reliability of transfers of CS are not driven exclusively by wildlife habitat or producer income. Since the ASC and water quality are valued at a much higher magnitude than either wildlife habitat or producer income they have more influence on the validity and reliability of CS transfers. Transfers of marginal WTP for the ASC and water quality based on the linear model are generally more valid and reliable than those based on the quadratic model, which may be driving the relatively better validity and reliability of transfers of CS based on the linear model (see Appendix D9 in). However, looking at changes in income in isolation from the other components of CS reveals that the linear model yields lower errors and tolerance levels than the quadratic model in 54% and 8% of cases, respectively. For isolated changes in wildlife habitat, the linear model yields lower errors and tolerance levels than the ‘relative’ (’absolute’) approach in 25% (79%) and 17% (75%) of cases, respectively. These results are similar to those observed for transfers of marginal WTP. A related insight is that when transferring CS values the functional relationship estimated for quantitative attributes matters less if the marginal values of these attributes are small relative to the marginal values of the other attributes. Another factor influencing the validity and reliability of the linear and quadratic specifications is that extremely large errors or tolerance levels arise for levels approaching asymptotes for transfers based on the quadratic model. Asymptotes are not a factor for transfers based on the linear model.

Our results could differ if an alternative reconciliation approach was used. For instance, though the wildlife habitat attribute levels change by 10 percentage points in each watershed the difference relative to the baseline differs substantially across sites. The changes are 3 or 5 times the baseline for the Little, 2 or 3 times for the Salmon, 1.4 or 1.8 times for the Credit, and 1.3 or 1.7 times for the Humber.[63] An alternative reconciliation approach, which falls outside the scope of this paper, involves comparing WTP across sites at attribute levels calibrated to represent the same proportional change from their respective status quos. For the current study, this could involve evaluating transfer validity and reliability for reasonable proportional changes in wildlife habitat (e.g., 10% or 20% increases in habitat at each site). Furthermore, we only examined linear and quadratic specifications for the quantitative variables. Our results could also differ if we assessed alternative specifications, such as the natural logarithm, or changed the models in other ways.

[63] The differences relative the baseline may explain why respondents in the Little and Salmon are more sensitive to changes in wildlife habitat relative to those from the two Ontario watersheds.

5.5. Conclusion

We sought to assess the validity and reliability of alternative approaches for reconciling differently defined goods or services for purposes of applied benefit transfer. We also examined how the validity and reliability of transfers varies with functional form assumed for quantitative attributes (linear and quadratic). In doing so, we used nearly identical choice experiments in four Canadian watersheds that sought to value changes in wildlife habitat (whose levels differed by watershed), water quality, and farm and forest producer income. Overall, the validity and reliability of our transfers are similar to the validity and reliability of transfers studied in the convergent validity literature. For transfers of quantitative attributes with different levels that have a quadratic functional form, our results suggest that transfers rooted in ‘relative’ preferences outperform those based on ‘absolute’ preferences. Furthermore, for these transfers the choice between reconciliation approach matters less when the attributes needing reconciliation have fairly similar levels, though only in the case of transfers of compensating surplus and welfare for changes in the attribute levels relative the status quo. Finally, though transfers based on the linear model specification result in more valid and reliable transfers of compensating surplus than the quadratic model, the same is not necessarily true for transfers of marginal WTP. We believe these results contribute to the literature on best practices for applied benefit transfer and will be of interest to other researchers and policy analysts.

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Chapter 6.

Conclusion

This dissertation makes several contributions to the literature and its findings have applications to resource and environmental management and policy. I review the main findings and provide examples of potential applications in this concluding chapter, which is structured as follows. First, to refresh the reader's memory I briefly review the main takeaways from each of the four studies, and then discuss some implications for management and policy. Finally, the dissertation closes with a general discussion of certain limitations and potential areas of further research.

6.1. Overview of Each Paper and Main Findings

The papers forming my dissertation contribute to the literature in two main areas: 1) private landowner preferences for characteristics of conservation programs; and 2) benefit transfer. Specifically, the paper presented in Chapter 2 sought to elicit private landowner preferences for the attributes of a voluntary payments-based wetlands conservation program using choice experiments in Southern Ontario's Grand and Upper Thames River watersheds. Two similar though distinct choice experiment versions were administered separately to farm and non-farm landowners. The data from the two versions were modeled independently using latent class models from which landowner WTA and the proportion of respondents who would be willing to participate in certain wetlands conservation programs were predicted. The results indicate that:

- Numerous landowners in the two watersheds are willing to conserve wetlands though their preferences for conservation program characteristics are heterogeneous and their participation or required financial compensation depends on the program's attributes.
- In general, the favoured program characteristics included: diverting smaller areas of land to conservation; diverting marginal rather than productive land; converting land to trees, followed by either meadow or wetlands; technical help; no public recognition; and higher financial compensation.
- Many types of landowners are willing to protect or restore wetlands, including those who are commodity producers and those who are not.
- Marginal WTA and CS estimates are in the range of those from similar studies.

The paper forming Chapter 3 assessed the validity and reliability of transferring landowner marginal WTA and CS values resulting from the producer-focused choice experiments in Chapter 2. The data were modeled in WTA space and benefit transfers were assessed by calculating directional and non-directional transfer errors as well as conducting standard convergent validity hypothesis tests. The results from this study indicate that:

- Overall, the reliability and validity of transfers of landowner WTA between the two sites is similar to the reliability and validity of transfers of WTP found in previous convergent validity studies.
- Including interactions of socio-demographic variables with the alternative specific constant does not substantially change transfer reliability and some aspects of validity. However, these interactions do inflate the tolerance levels estimated for transfers of the alternative specific constant and compensating surplus.
- Non-directional errors calculated according to the equation introduced in Chattopadhyay (2003) may be much larger than the corresponding directional errors and this occurs when the values being compared have similar magnitudes and opposing signs.

The paper presented in Chapter 4 assessed the validity and reliability of transfers of predicted program participation market shares (the proportion of respondents predicted to participate in a wetlands conservation program relative to maintaining the status quo). To provide context, these results were contrasted with an assessment of the validity and reliability of transfers of CS values derived from the same model. The data, which were modeled using a random parameters logit model, were from the non-producer choice experiments outlined in Chapter 2. Both transfers were assessed by calculating transfer errors and using convergent validity hypothesis tests. The main findings of this study are that:

- Transfers of predicted program participation market shares appear valid and reliable, especially relative to the validity and reliability of transfers of the CS values. However, given the differences in how the two measures are calculated further research is required to clarify if transfers of such market shares are reliable and valid enough for policy analysis.
- The validity and reliability of transfers of CS are similar to the validity and reliability reported for existing convergent validity studies using WTP values.

The fourth paper, included as Chapter 5, examined alternative approaches to reconciling quantitative choice experiment attributes with levels that differ across sites when conducting benefit transfer. Three alternative approaches for transferring such quantitative variables were assessed, including one based on a linear model specification and two approaches based on a quadratic specification (‘relative’ and ‘absolute’). The data are from choice experiments that elicited the preferences and values of residents living in or near 4 Canadian watersheds for improving water quality and the extent of protected wildlife habitat in each watershed (and associated declines in farm and woodlot producer income as well as increases in the respondent's taxes). The data were modeled using a random parameters logit. The transfers were assessed by calculating directional transfer errors and by conducting convergent validity hypothesis tests. The performance of the alternative reconciliation approaches was compared based on these measures. The results of this study indicate that:

- Although preferences are heterogeneous and differ across certain watersheds, respondents generally prefer improved water quality and to a certain extent larger areas of the watershed protected as wildlife habitat, while they generally dislike declines in producer income as well as higher tax payment levels.
- For all three reconciliation approaches, the transfers of marginal WTP and CS between the case study sites are of similar validity and reliability to previous convergent validity studies.
- Transfers based on the quadratic specification grounded in 'relative' preferences are more valid and reliable than transfers rooted in 'absolute' preferences.
- For transfers of non-marginal monetary values the choice between the 'relative' and 'absolute' reconciliation approaches matters less when the attributes needing to be reconciled have fairly similar levels.
- For CS, transfers based on the linear specification are more valid and reliable than both sets of transfers based on the quadratic model, although this does not necessarily hold for transfers of marginal WTP.

6.2. Implications for Resource and Environmental Management or Policy

The research that forms my dissertation can inform related policy development and analysis as well as resource and environmental management. For example, elements of each paper could inform the ongoing efforts to remedy environmental problems related to the runoff of nutrients into Lake Erie. Recently, the Canadian and Ontario governments released the Canada-Ontario Lake Erie Action Plan for reducing phosphorus loadings to the lake (Environment and Climate Change Canada and Ontario Ministry of the Environment and Climate Change 2018). The plan is an outcome of a 2016 binational agreement between Canada and the United States to reduce the amount of phosphorous entering Lake Erie (Nutrients Annex Subcommittee Objectives and Targets Task Team 2015). This agreement commits Canada and Ontario to achieving a 40% reduction in total phosphorous entering the lake's central and western basins, as well as a 40% reduction in soluble phosphorous entering the lake via the Thames and Leamington River watersheds (below 2008 levels by 2025). The plan takes an adaptive management approach and involves an exhaustive list of actions and research. The actions include conserving and restoring wetlands and involve a variety of financial incentives for private landowners (e.g., existing cost-share programs and a new $4.1 million commitment to financially support the implementation of best management practices or other approaches to reduce phosphorous runoff). The planned research includes examining the effectiveness of wetlands for reducing phosphorous runoff as well as evaluating the feasibility of using economic incentives. Multiple stakeholders are involved, including municipal, provincial, and federal governments, First Nations, conservation authorities, non-governmental organizations, and the agricultural industry. Indeed, certain stakeholders are already developing strategies for reducing phosphorous runoff. For example, the Thames River Phosphorus Reduction Collaborative has been working towards meeting the demands of the binational agreement since 2016 (Thames River Phosphorus Reduction Collaborative 2018).

My research suggests a few lessons. The results of Chapter 2 regarding private landowner preferences for protecting or restoring wetlands are directly applicable, though wetlands would need to be properly situated to achieve reductions in phosphorous runoff in order to maximize benefits.[64] These results suggest that landowners are more receptive to protecting existing wetlands rather than creating new or restoring former wetlands. They also indicate that, since certain groups of landowners are more receptive than others, conservation programs could be tailored to different groups based on their willingness to participate (or in the context of financial incentives, their willingness to accept compensation). While each group has certain distinct

[64] There are potential challenges with preserving or restoring wetland habitat in Ontario. First, it can be challenging to identify areas for wetland restoration, such as areas where wetlands that have previously been drained, or creation since doing so requires detailed information on the land base as well as analysis (Uuemaa et al. 2018). Furthermore, creating wetlands in areas where they were not previously established may face higher engineering costs and the ecological benefits of such wetlands may not be substantial if they are not well enough connected to current or historical wetlands. An additional challenge relates to gaining approval for restoring or creating wetlands. For instance, the Ontario Lakes and Rivers Improvement Act "[r]equires approval for the construction, alteration and operation of water control structures, some of which may be used to restore or enhance wetland habitat" (Ontario Ministry of Natural Resources and Forestry 2017).

preferences, in general private landowner participation in wetlands conservation programs could be increased if the program: allows them to divert smaller areas of land to conservation purposes; targets marginal agricultural land; protects existing wetlands with treed buffers; offers technical help and not public recognition; and uses financial incentives (higher incentives will yield more participation). Finally, such programs should not necessarily be limited to those with larger land holdings or commodity producers since other types of private landowners are also willing to participate (though actions need to be substantive enough to reduce phosphorous runoff).

The papers included in Chapters 3 through 5, which are those related to benefit transfer, also have a few implications (as part of economic analyses of the action plan's components). The results of these studies suggest that policy analysts can use transfers of landowner WTA in the same way they currently use transfers of WTP, for instance in benefit-cost analysis, since they have similar validity and reliability. Furthermore, market shares may also be transferred to inform the development or analysis of conservation programs or actions since these transfers are more valid and reliable than transfers of economic values. Finally, the results of Chapter 5 indicate that the economic benefits of the actions, for instance regarding improvements in water quality, may be assessed by transferring values from other regions of Ontario or even other Canadian provinces.

Since the Canada-Ontario Lake Erie Action Plan takes an adaptive management framework it is worth noting that benefit transfer could play a role in this approach (assuming a desired criteria includes measuring non-market benefits or costs). Adaptive management is a decision-making approach for managing the environment and natural resources in dynamic uncertain social-ecological systems (Gregory et al. 2006). The key characteristic of this approach is that it allows managers to learn about the system during the implementation of management actions by testing hypotheses. If certain hypotheses relate to non-market economic values then benefit transfer is useful since it may not be feasible to conduct primary research throughout the adaptive management cycle, especially since the latter is an iterative process.

There are additional lessons for applied benefit transfer or future convergent validity studies. For instance, future convergent validity studies should be cautious when using non-directional errors based on Chattopadhyay's (2003) equation when values are of similar magnitude with opposing signs as the errors may be unreasonably large (an alternative would be to take the average of the directional errors). Furthermore, when transferring values resulting from choice experiments the approach to reconciling quantitative attributes with different levels matters. In general, analysts should use approaches rooted in 'relative' preferences for transfers of values resulting from quadratic variable specifications or use linear specifications.

6.3. Limitations and Extensions

Each of the studies contained in my dissertation has certain potential limitations, many of which are noted in the previous chapters. Overall, while the research is nested in resource and environmental management it takes an economic perspective, specifically non-market valuation. As with any approach, this perspective is not immune to criticism or limitations. For example, McCauley (2006) argues that nature should be conserved because of its intrinsic value, rather than its instrumental value, and should thus not be assigned monetary values. However, non-market valuation is not necessarily less valid than other approaches to the same problem and provides additional information to decision or policy makers (Freeman et al. 2014). Valuation is, however, not necessarily desirable in all situations. For instance, the economic valuation framework is only appropriate for marginal changes in ecosystem services (Fisher et al., 2008). Two key implications for valuation, in the context of ecosystems, emerge from marginality. First, the scale of the change needs to be meaningful. This involves determining the appropriate scale for the unit change. Fisher et al. (2008) provide the example that it is neither appropriate nor meaningful for this unit to be the world's forests and put forth the landscape scale as the largest possible scale (though note the need for more research). Second, marginality assumes that the response of an ecosystem to small changes in structure or function should not cause large step changes ecosystem services. For example, valuation is not appropriate if the change results in an environmental system flipping from one state to another (for example due to non-linearties or threshold effects).[65] This second implication also suggests that valuation is only appropriate if the quantity of the ecosystem structure, from which the ecosystem service being valued flows, is above the safe minimum standard (Fisher et al. 2008). Finally, valuation is not the only applicable technique. The toolbox for informing problem

[65] Certain studies do incorporate threshold effects into their valuations, such as Hein's (2006) assessment of the net benefit of controlling eutrophication in a shallow lake.

solving in the environmental realm contains alternative techniques for evaluating policies or decisions (e.g., multi-criteria analysis) — there is no perfect method for all situations.

Further limitations are related to using choice experiments as the primary valuation technique. First, choice experiments assume that respondents make rational decisions when completing the choice tasks, which may not be the case (Jackson 2005). Similarly, the technique — and stated preferences generally — have received criticism for being too hypothetical among other biases (see Hensher (2010) or Rakotonarivo et al. (2016) for a review).[66] The debate is rooted in whether respondents state their true preferences in response to choice experiment questions — is the technique incentive compatible?[67,68] There is support for the choice experiment technique. For instance, Lusk and Schroeder (2004) compared values derived for steak attributes from a hypothetical choice experiment with those from a simulated market setting and found similar marginal WTP values (although the probability of purchase was higher for choice experiments as was total WTP). Furthermore, Hainmueller et al. (2015) found that choice experiment results mirror actual choices for immigration policy preferences in Switzerland (although this paper is not about valuation). However, Rakotonarivo et al. (2016) systematically reviewed 107 environmental choice experiment studies published

[66] The debate over the suitability of stated preferences reached its height after the contingent valuation method (CVM) was used to assess the non-use monetary damages of the Exxon Valdez oil spill off the coast of Alaska in 1989, which were used in court to set punitive damage costs. At the time the debate led to a National Oceanic and Atmospheric Administration blue ribbon panel on the CVM, from which a number of recommendations resulted on how to implement future CVM-based research (Arrow et al. 1993). For a review of the debate in the early 1990’s see Diamond and Hausman (1994), Hanemann (1994), and Portney (1994). The debate is ongoing (Carson 2012; Hausman 2012; Kling et al. 2012).

[67] Respondents may not state their true preferences to influence the survey’s results (Whittington et al. 2017). Respondents to a stated preferences survey about payments to landowners for conservation actions may behave strategically to secure the program by stating a lower WTA if they are unsure if the program will be provided (e.g., if the program administrator is weighing costs) or a higher than minimum WTA if they feel that the program will be provided (to obtain a higher payment level). Similar rationale applies to WTP. In this case, respondents may state a higher WTP if they are unsure the program bringing about the environmental changes will be offered (and want the program) or a lower WTP if they think it will be provided (to reduce their eventual expenses).

[68] As noted in Chapter 1, Whittington et al. (2017) highlights that the WTA measure may result in a higher rate of non-conforming responses (e.g., rejected scenarios, protest votes, and non-response) and list a few reasons, one of which is that payments may be viewed as unethical. Similarly, certain respondents to our landowner surveys were not willing to accept compensation from the government on religious grounds. Indeed, traditional Mennonite communities in the region surveyed have historically not accepted government assistance for conservation actions, instead bearing the costs themselves (Peters 2002). While they respect government, Mennonites do not want to be beholden to it — they believe in a clear separation of church and state.

between 2003 and 2016 to assess the validity and reliability of the technique. They concluded that, while the technique is useful for non-market valuation, the resulting values should be treated with some caution. As outlined by Whittington et al. (2017) stated preference questions about public goods can be formatted such that they are incentive compatible. However, doing so is more difficult when using WTA in a private good setting, and as noted by Whittington et al. (2017), landowner conservation actions are essentially private goods. Research is ongoing in this area, although I took certain actions to address these issues, including using a "cheap talk script" and follow-up questions, as noted earlier. In addition following best practices, such as those outlined by Johnston et al. (2017), can improve the validity and reliability of non-market values elicited via choice experiments (this paper was not available when I was designing the choice experiment surveys, though I relied on other sources such as Louviere et al. (2000), Holmes and Adamowicz (2003), and Hensher et al. (2005)). The choice experiments used in my thesis were done over 5 years ago and the literature has advanced quite a bit since their implementation. For instance, Vossler et al. (2012) shows that choice sets with two alternatives are incentive compatible if they meet a given set of conditions compared to choice sets with more alternatives (I used three alternatives per choice set in all surveys). Furthermore, there is no perfect method for valuation (e.g., certain other techniques are not capable of assessing the full spectrum of values). Fully investigating this issue in the future could involve eliciting monetary values and preferences using a variety of techniques and then triangulating the results.

An additional limitation of my research is the calibration of respondent certainty of choice as an attempt to limit hypothetical bias. There are alternative techniques, including the set of recalibration rules developed by Ready et al. (2010) that they found to reduce this bias, as well as the approach I took which involved weighting the utility function by certainty score as suggested by Hensher et al. (2012) and used in Beck et al. (2013). However, recent stated preference guidance in Johnston et al. (2017) advises caution when using such auxiliary questions for calibration since doing so lacks a basis in theory and is not objective. Thus, perhaps not calibrating for certainty is the approach I should have taken.[69] Regardless, in the third paper (Chapter 4) I did assess transfers

[69] Beck et al. (2016) compared multiple options for calibrating responses for certainty. One of their findings was that certainty weighting yields results similar to not calibrating for certainty in terms of addressing hypothetical bias. Furthermore, they found that recoding uncertain responses introduces more bias than doing nothing or weighting by certainty.

based on models that were calibrated for certainty using the Beck et al. (2013) approach and were not calibrated and found both models yielded similarly valid and reliable transfers.

An additional concern is that certain mean marginal willingness to accept or pay values estimated resulting from my research were quite large (outside the range of the bid values used). For instance, the mean marginal WTP for improvements in water quality presented in Figure 5.2 are larger than the maximum bid value of $200 employed in the choice experiment. This discrepancy suggests the presence of fat tailed distributions and that the highest level of the payment attribute was set too low (MacKerron et al. 2009; Brouwer et al. 2015). Approaches for addressing the issue of fat tails have been developed, however, I completed the tests of transfer validity and reliability using the unadjusted estimates similar to Brouwer et al. (2015). It is possible that, if fat tails similarly affect estimates at all case study sites, the results of the transfer assessments may be relatively unaffected by this measurement error.

Though including the acreage attribute in the landowner choice experiments allowed me to directly elicit preferences for the area diverted to wetlands conservation there are limitations to including this attribute. First, respondents who do not own enough land to participate in any of the wetlands conservation alternatives are not able to credibly answer and must be removed from the analysis (or may not respond initially). Second, adding acreage as an attribute introduces possible issues with endogeneity as the number of acres to be enrolled in a given conservation program is typically chosen by the landowner (i.e., the area enrolled depends on the program's other attributes and levels). A more appropriate approach for including area in the choice model is to use a discrete continuous approach (Greiner et al. 2014). In this case there is a discrete component eliciting landowner preferences for the key conservation program characteristics and a continuous component that follows which captures the decision about the area to enroll in the preferred alternative. There are a few examples of discrete continuous choice used in contingent valuation studies that elicit landowner WTA for participation in agri-environmental programs (e.g., Lohr and Park 1995; Lynch et al. 2002). Greiner et al. (2014) appear to have used discrete continuous choice in a choice experiment in an agri-environmental program context, but do not report on the results of the continuous portion in this or subsequent publications (i.e., Greiner 2015; Greiner 2016).

There are additional concerns about the farm and woodlot owner income attribute. This attribute was included to make the scenario more realistic and to elicit preferences and willingness to pay for negative effects on these producers resulting from actions taken to improve the other attributes (i.e., wildlife habitat and water quality). One concern is that the farm and woodlot owner income attribute at least in part measures willingness to pay for altruism, or concern for the well-being of others, which may have implications for benefit-cost analyses (Johansson 1992; McConnell 1997). For instance including these values could lead to double counting and a respondent's motivation dictate whether their altruistic value should be included in a benefit-cost analysis in the first place (assessing such motivations in a survey is a difficult task). Another concern is that this attribute is confounded with the others in that the wildlife habitat and water quality attributes must change for farm or woodlot owner income to decline (i.e., this attribute is not independent).

Another notable limitation was the low response rates, though as previously noted they are in the range of other similar studies. However, the research may suffer from non-response bias if the results do not reflect the preferences and values of those who did not respond. From a practical perspective, I would advise caution with future studies that choose to use Canada Post's Admail service since some responses came from non-targeted postal codes, while the occasional household received a follow-up postcard or questionnaire but did not receive the initial questionnaire. However, contacting farmers and other landowners using other means may not be feasible.

My research, especially the study assessing private landowner preferences for wetlands conservation from Chapter 2, could be extended through integration with a biophysical model of ecosystem services provided by wetlands. For example, the choice model could be coupled with a hydrologic model such as that developed by Pattison-Williams et al. (2017) to determine the impacts of varying conservation scenarios, that could be constructed from the landowner choice experiment, on phosphorous exports. The benefits of such actions, for instance in terms of water quality improvements, could even be calculated via benefit transfer using values from Chapter 5. Furthermore, the benefit transfer assessments only reflect the conditions at the sites included in my studies and only for those periods of time considered. Transfers of WTA and market shares should be assessed in other conditions (e.g., between sites that are more distant, different types of respondents, etc.). For example, an additional analysis could include comparing the validity and reliability of transfers between the same sites at different periods of time. This would involve implementing the same choice experiment surveys in the same watersheds at different points in time. Such an assessment would reflect the actual conditions under which benefit transfer is used and enable researchers to determine if geographic or temporal differences are the main drivers of generalization error.

In addition, it would be interesting to investigate the relationship between the economic estimates such as willingness to accept or compensating surplus and market shares in the context of transfers since both types of estimates are derived from the same model. Schlereth et al. (2012) note that willingness to pay "is the price at which a consumer is indifferent between buying and not buying a product." In other words, it is the dollar value at which the predicted probability of selecting an alternative specification is balanced with the probability of selecting the status quo (i.e., a share of 50%). Given this, it could be informative to investigate the mapping of predicted participation market share estimates onto corresponding compensating surplus values and assess how this relates to the validity and reliability of transfers of each type of estimate. Among other things, this research could potentially inform the threshold at which transfers of market shares could be considered valid and reliable (in the same sense as economic values).

Finally, welfare estimates derived from choice experiments are random variables since the parameters from which they are derived are random (Bockstael and Strand 1987). As such, the directional and non-directional errors calculated as part of convergent validity analyses are also random since they are the product of random WTP or WTA values. Thus, when comparing the performance of alternative approaches to benefit transfer, as was done in Chapter 5 when reconciling attributes with different levels, researchers could employ statistical tests rather than simply comparing the magnitude of the errors. For instance, Poe et al.'s (2005) complete combinatorial test could be modified to determine if the errors resulting from the alternative approaches are statistically different. In future research, I intend to investigate this, and the other areas inquiry identified above, to better understand the most robust way to estimate and transfer non-market values for use in policy analysis.

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Appendix A.

Supplementary Material for Chapter 2

The Latent Class Model

The standard approach to analyzing choice experiment data is the random utility model (RUM) which postulates that individuals choose among alternative goods or services according to the utility they derive from them (McFadden, 1974). Following Train (2009), the utility that individual *n* gains from alternative $j = 1, 2, 3, \ldots, J$ on choice occasion *t* can be represented as U_{njt}. When faced with a choice among multiple alternatives, an individual will select alternative *j* if the utility gained from it is larger than the utility gained from the others ($U_{njt} > U_{nit}\ \forall\ j \neq i$). While utility is not directly observable, an individual's choices among a set of alternatives are and can be used to infer the utility derived from choosing a particular alternative (Hoyos, 2010). The random utility model assumes that utility is divisible into deterministic and stochastic portions (Train, 2009). The deterministic portion (V_{njt}) accounts for the attributes of the good or service (x_{njt}) as well as characteristics of participants (d_n).

$$V_{njt} = \alpha + \beta x_{njt} + \gamma d_n \qquad \text{(A1)}$$

β and γ are vectors of coefficients corresponding to the attributes and characteristics and α is a constant term. The random portion (ε_{njt}) accounts for unobservable attributes and characteristics that affect utility and is typically assumed to enter utility additively (Hoyos, 2010).

$$U_{njt} = V_{njt} + \varepsilon_{njt} \qquad \text{(A2)}$$

For estimation, the RUM is reformulated as a probabilistic model and a logit distribution is assumed yielding the conditional logit model (McFadden, 1974; Train, 2009).

$$\mathrm{Pr}_{njt} = \frac{e^{\mu\beta' x_{njt}}}{\sum_j e^{\mu\beta' x_{njt}}} \qquad \text{(A3)}$$

β' represents the part-worth utilities associated with the attributes and μ is the scale parameter.[70] A key assumption is that respondents have homogeneous preferences. Latent class models relax this assumption by grouping respondents with similar preferences together. Preferences are homogeneous within classes, but heterogeneous across classes. The probability of individual *n* choosing alternative *j* on choice occasion *t* is now conditional on their membership in class *s* (Boxall & Adamowicz, 2002; van Putten et al., 2011). The probability that individual *n* is a member of class *s* is also a logit. In this case σ is a scale factor (assumed to equal 1), λ_s is a vector of parameters for class s, and Z_n is a vector of characteristics, known in Latent Gold as ‘covariates’, influencing the segmentation (latent attitudes and perceptions, and sociodemographic characteristics).

$$\mathrm{Pr}_{njt} = \sum_{s=1}^{S} \left[\frac{e^{\sigma\lambda_s Z_n}}{\sum_{s=1}^{S} e^{\sigma\lambda_s Z_n}}\right] \left[\frac{e^{\mu_s \beta_s' x_{njt}}}{\sum_j e^{\mu_s \beta_s' x_{njt}}}\right] \tag{A4}$$

Maximum likelihood estimation is used to estimate the latent class model.

[70] For a single data set μ is assumed to equal 1. However, different data sets may have different scale parameters. We used the Swait & Louviere (1993) test to assess whether the data from the two watersheds can be combined for each version of the survey. Results of this test show that the data can be combined.

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Appendix B.

Supplementary Material for Chapter 3

B1. The Choice Experiment

The preamble, which sets up the choice experiment, and the first choice set are provided below. The Grand and Upper Thames choice experiments are identical, with the exception of the watershed names.

Section 4: Incentives for Enhancing & Restoring Wetlands

Suppose that in an effort to enhance and restore wetlands within and adjacent to the Grand River watershed, the government offered a voluntary program that provided incentives to landowners to set aside some of their lands. The incentives would include public recognition, technical assistance, and/or annual payments to acknowledge their provision of an environmental service to society. The land could be converted from manicured lawns, old fields, or other to: (i) meadow or trees to help retain nearby wetlands; or (ii) wetlands if appropriate.

PROGRAM CONDITIONS:

Participating landowners would:

- Sign a 5-year contract to enroll some of their land and receive incentives (i.e., public recognition, technical assistance, and/or annual payments).
- Have the opportunity to renew the contract, or transfer/terminate it if the land is sold.
- Enroll land that is in addition to existing commitments under government or non-government programs and legal requirements.
- Have a say in what type of land conversion activities are implemented (i.e. whether to convert land to meadow, trees, or wetlands). All planting/restoration costs would be paid for by the government (on top of any financial incentive to you).

We would now like to ask you to evaluate several program options.

On each of the next few pages, you'll be presented with a set of 2 voluntary programs considered by the government. We ask you to choose between PROGRAM A, PROGRAM B, or NO PROGRAM.

PROGRAM CHARACTERISTICS:

Each program is described by the following range of PROGRAM CHARACTERISTICS:

Conversion activity	➡ land can be converted to Meadow, Trees, or Wetland
Number of acres	➡ area converted can be 0.5, 1, or 1.5 acres
Technical assistance	➡ can be Yes or No, depending on whether or not **technical experts** from the government or other groups are involved.
Public recognition	➡ can be Yes or No, depending on whether or not **signage** on property, stewardship **banquets**, & **awards** are provided.
Annual payments to you	➡ can be \$0 to \$250 per year (positive amounts acknowledge your provision of an environmental service to society).

Please consider the options carefully - as if you were entering into a real contract with the government - since the program would have a limited budget and could only fund a limited number of projects.

SET 1:

17a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Wetland	Meadow	---
Number of acres	1.5 acres	1 acre	---
Technical assistance	No	No	---
Public recognition	Yes	No	---
Annual payments to you	$200/year	$200/year	$0/year
Please choose only one	☐	☐	☐

17b. On a scale 1 to 10, how certain are you about the program choice you made above?
Please circle the number that best represents your answer if ***1 equals not at all certain*** *and* ***10 equals very certain****.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

B2. Estimated Variance-Covariance Matrix and Standard Deviation Parameters

Table B1: Estimated Variance-Covariance Matrix and Standard Deviation Parameters

	Variance Covariance Matrix						Standard Deviation
	ASC	Acres	Land Type (productive)	Activity: Wetland	Activity: Trees	Recognition (yes)	
Grand River Watershed							
ASC	99.5104***						9.9755***
	(23.5285)						(1.1793)
Acres	-0.1102	0.8529***					0.9235***
	(1.7940)	(0.3188)					(0.1726)
Land Type	3.1880	0.7812	7.9465***				2.8190***
(productive)	(3.7216)	(0.4864)	(1.8046)				(0.3201)
Activity:	1.8104	0.0265	-2.0463**	7.3829***			2.7171***
Wetland	(3.8328)	(0.4768)	(1.0183)	(2.0545)			(0.3781)
Activity:	-0.7794	-0.2488	0.0131	-4.2776***	7.2241***		2.6878***
Trees	(3.8037)	(0.4516)	(0.9425)	(1.3255)	(1.8603)		(0.3461)
Recognition	6.5722	-0.3985	-1.9156	-0.5798	0.2148	7.2139***	2.6859***
(yes)	(4.7107)	(0.5223)	(1.3039)	(1.2723)	(1.3523)	(2.1849)	(0.4067)
Upper Thames River Watershed							
ASC	67.5628***						8.2197***
	(15.8763)						(0.9658)
Acres	-1.1393	0.4610**					0.6790***
	(1.3135)	(0.2119)					(0.1560)
Land Type	0.4509	0.1145	3.1597***				1.7776***
(productive)	(2.5714)	(0.2423)	(0.8687)				(0.2444)
Activity:	1.1975	0.5278*	-0.5894	3.7843***			1.9453***
Wetland	(2.9396)	(0.3159)	(0.5747)	(1.1955)			(0.3073)
Activity:	1.1034	-0.3713	-0.4245	-1.3278*	2.0837***		1.4435***
Trees	(2.7257)	(0.2614)	(0.5337)	(0.6939)	(0.7860)		(0.2723)
Recognition	-0.1518	-0.1216	-0.0870	1.6163**	-0.6822	2.3977*	1.5485***
(yes)	(3.4528)	(0.3665)	(0.7594)	(0.8085)	(0.6920)	(1.3231)	(0.4272)

B3. Pooled Models for the Swait and Louviere Test

Table B2: Pooled Models in Willingness to Accept Space Serving as Inputs into the Swait and Louviere Test

Variables	Pooled 1	Pooled 2
Mean[a]		
ASC	0.6116	0.6084
	(0.5272)	(0.5251)
Acres	-0.2707***	-0.2691***
	(0.0699)	(0.0697)
Land Type (productive)	-2.3224***	-2.3241***
	(0.1730)	(0.1729)
Activity: Wetland	-1.1136***	-1.1128***
	(0.1748)	(0.1751)
Activity: Trees	1.1867***	1.1871***
	(0.1657)	(0.1659)
Recognition (yes)	-0.4009*	-0.4073*
	(0.2095)	(0.2093)
Elements of the Lower Triangular Cholesky Matrix		
ASC × ASC	9.1330***	9.1488***
	(0.7368)	(0.7379)
Acres × ASC	-0.0421	-0.0423
	(0.1114)	(0.1110)
Land Type × ASC	0.3247	0.3226
	(0.2179)	(0.2167)
Wetland × ASC	0.1902	0.1923
	(0.2460)	(0.2466)
Trees × ASC	-0.0025	-0.0019
	(0.2394)	(0.2393)
Recognition × ASC	0.2665	0.2690
	(0.3042)	(0.3036)
Acres × Acres	-0.7509***	-0.7509***
	(0.1133)	(0.1116)
Land Type × Acres	-0.5110*	-0.5207*
	(0.2860)	(0.2797)
Wetland × Acres	-0.5049	-0.4993
	(0.3270)	(0.3260)
Trees × Acres	0.5006	0.5001
	(0.3081)	(0.3078)
Recognition × Acres	0.3074	0.3088
	(0.3816)	(0.3785)
Land Type × Land Type	-2.2061***	-2.2111***
	(0.1876)	(0.1876)
Wetland × Land Type	0.5858**	0.5858**
	(0.2345)	(0.2335)
Trees × Land Type	0.0357	0.0330
	(0.2254)	(0.2248)
Recognition × Land Type	0.4232	0.4306
	(0.2906)	(0.2891)

Variables	Pooled 1	Pooled 2
Wetland × Wetland	2.1597***	2.1727***
	(0.2420)	(0.2393)
Trees × Wetland	-1.0739***	-1.0854***
	(0.2644)	(0.2634)
Recognition × Wetland	0.2695	0.2589
	(0.3450)	(0.3406)
Trees × Trees	1.7303***	1.7349***
	(0.1903)	(0.1904)
Recognition × Trees	-0.2170	-0.2108
	(0.3317)	(0.3298)
Recognition × Recognition	-2.0218***	-2.0291***
	(0.2706)	(0.2690)
Scale		
Constant (θ)	-0.3807*	-0.4201**
	(0.2055)	(0.1920)
Grand dataset indicator	-0.0705	
	(0.1241)	
Tau (τ)	-0.5253**	-0.5298**
	(0.2114)	(0.2131)
Model Statistics		
Observations	15,915	
Log-likelihood	-2929.00	-2929.16

[a] Coefficients represent the negative of WTA values scaled by 100 since the payment attribute was divided by 100 to aid model convergence. Standard errors appear in brackets below the corresponding coefficient.

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

B4. Explaining Extremely Large Non-Directional Errors

To examine how errors estimated by the non-directional Chattopadhyay (2003) equation are impacted when values being compared are of opposing signs assume two hypothetical sites, Site A and Site B. The average WTA at Site A is negative, while the average WTA at Site B is positive. To show the impact on errors when the magnitudes of the values being compared approach one another, Site B's WTA is set at a constant \$100 and WTA at Site A is allowed to vary. Thus the computation reduces to Equation B.1.

$$Chattopadhyay\ Error\ (\%) = \left|\frac{WTA_{Site\ A} - WTA_{Site\ B}}{(WTA_{Site\ A} + WTA_{Site\ B})/2}\right| = \left|\frac{WTA_{Site\ A} - 100}{(WTA_{Site\ A} + 100)/2}\right| \quad \text{(B.1)}$$

Trial values of WTA at Site A are used to calculate directional and non-directional Chattopadhyay errors (Table B3). The Chattopadhyay errors are also plotted against the trail values at Site A (Figure B1).

Table B3: Non-Directional Transfer Errors

Values		Transfer Errors (%): Sites A and B		
Site A	Site B	Directional: Policy Site A	Directional: Policy Site B	Chatto-padhyay
-\$25	\$100	125	500	333
-\$50	\$100	150	300	600
-\$75	\$100	175	233	1400
-\$85	\$100	185	218	2467
-\$95	\$100	195	205	7800
-\$96	\$100	196	204	9800
-\$97	\$100	197	203	13,133
-\$98	\$100	198	202	19,800
-\$99	\$100	199	201	39,800
-\$100	\$100	200	200	*Undefined*
-\$101	\$100	201	199	40,200
-\$102	\$100	202	198	20,200
-\$103	\$100	203	197	13,533
-\$104	\$100	204	196	10,200
-\$105	\$100	205	195	8200
-\$115	\$100	215	187	2867
-\$125	\$100	225	180	1800
-\$150	\$100	250	167	1000
-\$175	\$100	275	157	733

The results make clear: 1) that the Chattopadhyay error is undefined when the magnitudes are equal but signs oppose; and 2) as the magnitudes of WTA from the two sites approach one another the Chattopadhyay errors become extremely large. Indeed, the value of Site A at which its magnitude is equal to Site B's WTA is a vertical asymptote — the errors will come close though never touch this line. Note that the directional errors are around 200% at this point.

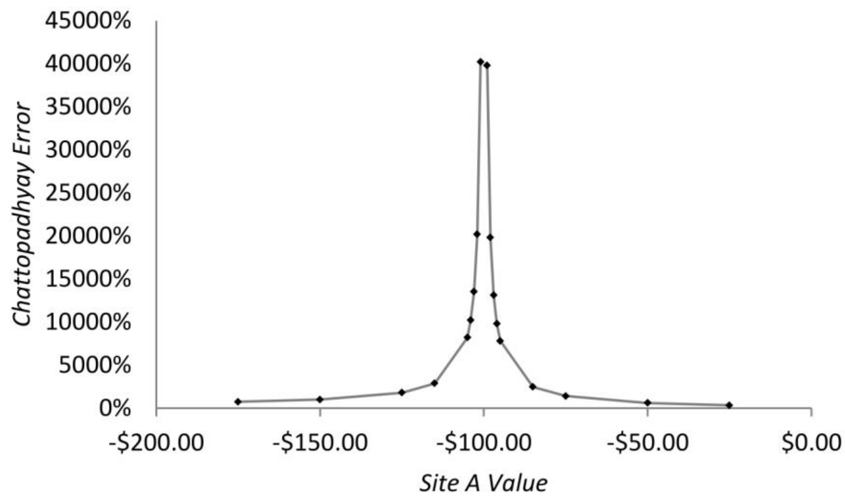

Figure B1: Chattopadhyay Errors for Transfers between Site A and Site B

Though Chattopadhyay's approach to calculating non-directional errors was recommended by Kaul, Boyle, Kuminoff, Parmeter, & Pope (2013), we suggest caution for future convergent validity studies. We recommend that this approach only be used in situations where the estimates being compared are of the same sign. While further study is required, an alternative procedure for calculating non-directional errors could be as simple as taking the average of the directional transfer errors. This simple approach would work for tolerance levels too since they are also directional.

B5. Sensitivity of our Results to Interactions with Demographic Characteristics

We ran two additional model specifications as part of the sensitivity analysis and conducted validity and reliability tests using willingness to accept and compensating surplus estimates derived from these models. Our goal was to explore the impact of interacting demographic characteristics with the alternative specific constant (ASC) term, though we ran an additional specification without such interactions since the data used is subset of that employed in the main text due to missing observations on each demographic characteristic. We included five demographic characteristics: gender (is female); age (age in years); education (holds a post-secondary education); employment status (is employed full or part-time); and income (is a member of a household that at least earns the sample's median household income).

The models were largely run using the procedures outlined for those models presented in the main text. However, given the time required to explore for local and global maximums we only ran a single iteration for each model in this appendix. For all models in Table A5 and the initial pooled models in Table A6 ("Pooled 1") we used starting values from the models presented in the main text for the non-interacted parameters (the starting values for the parameters representing an interaction were each set at 0). The second set of pooled models ("Pooled 2") used starting values from the initial pooled models ("Pooled 1"). The marginal willingness to accept (WTA) and compensating surplus (CS) values derived from the model without demographic interactions were estimated using a procedure identical to that used for the models in the main text. For the model with demographic interactions, the main difference in the procedure used to derive these estimates is that the variables representing the interacted demographics were set at their mean values when predicting WTA and CS (i.e., we did not use these interactions to adjust for differences in demographic characteristics as our samples are reasonably similar). Finally, validity and reliability were assessed using the techniques outlined in the main text.

Notably divergent results of our equivalence tests motivated us to model an additional specification with significant demographic variables only. Our goal with this specification was to assess whether dropping insignificant variables changed the results related to the estimated tolerance levels. As such, we did not complete the Swait &

Louviere (1993) test to compare model parameters and we only provide limited interpretation of the validity and reliability results flowing from this model since they are very similar to those generated from the model with all demographic interactions. The starting values used for this model were those from the model with all demographic interactions.

B5.1 Respondent Characteristics

Since the data is a subset of that used in the main text we begin by examining the demographic and owned land characteristics of our samples (Tables A3 and A4). Our results are very similar to those of Tables 3 and 4 of the main text, though an additional characteristic differs significantly across the Grand and Upper Thames samples (the area of land holdings at the 10% level of significance). In the samples used for the sensitivity analysis respondents from the Upper Thames watershed are still generally older and more educated than respondents from the Grand watershed.

Table B4: Comparing Respondent Demographic Characteristics Across Watersheds

Respondent Characteristics[a]	Data Type[b]	Watershed		Test Results
		Grand	U. Thames	
Gender (%)				
Male	Binary	79.3	78.1	
Female		20.8	21.9	
Age (Adults) (%)				
Under 25	Ordinal	1.1	0.3	***
25 to 44		26.0	15.7	
45 to 64		49.5	54.6	
65 or older		23.5	29.5	
Mean (years)	Continuous	53.9	57.1	***
Highest level of education (%)				
Less than high school	Ordinal	25.6	7.8	***
High school		29.6	32.6	
Post-secondary		44.9	59.6	
Employment status (%)				
Not in labour force	Categorical	20.3	17.6	
Unemployed		1.5	0.3	
Employed		78.2	82.1	
Household Income (%)				
Less than $10,000	Ordinal	1.5	0.3	
$10,000 to $29,999		5.9	5.6	
$30,000 to $49,999		17.4	15.7	
$50,000 to $74,999		22.6	20.1	
$75,000 to $99,999		21.6	26.9	
More than $100,000		32.0	31.0	

*, **, and *** indicate that the characteristic differs at the 90%, 95%, and 99% levels of significance, respectively

[a] Sample sizes are 319 for the Upper Thames watershed and 477 for the Grand watershed.

[b] Testing was completed using Pearson's chi-square tests for binary or categorical data (Fisher's exact test was used if a cell count less than 5) and Wilcoxon / Mann-Whitney tests for ordinal and continuous data.

The Grand sample still generally has a larger proportion of respondents reporting meadows and wetlands on their land than the Upper Thames sample, while the land holdings are generally larger for the Upper Thames sample than the Grand sample (reflecting the trend observed in the main text).

Table B5: Comparing Respondent Land Characteristics Across Watersheds

Land Characteristic[a]	**Data Type**[b]	**Watershed**		**Test Results**
		Grand	**U. Thames**	
Land Cover (%)				
Has forests	Binary	62.7	63.9	
Has meadows	Binary	27.9	17.6	***
Has wetlands	Binary	61.4	41.3	***
Has crop, pasture, or orchard (i.e., agricultural land cover)	Binary	91.6	93.4	
Land Use (%)				
Primary land use is agriculture or forestry	Categorical	80.8	85.5	
Primary land use is residential		17.3	13.3	
Primary land use is other		1.9	1.3	
Generated income from land in past 5 years (%)	Binary	87.4	90.3	
Area of Land Holdings				
Mean (acres)	Continuous	142.3	171.2	*
Farm or forest producerc (%)	Binary	79.1	83.4	

*, **, and *** indicate that the characteristic differs at the 90%, 95%, and 99% levels of significance, respectively

[a] Sample sizes for each characteristic are generally 477 in the Grand and 319 in the Upper Thames. Exceptions include: 'Has Wetlands' is 474 in the Grand and 317 in the Upper Thames; 'Land Use' is 469 in the Grand and 317 in the Upper Thames; and 'Farm or forest producer' is 465 in the Grand and 314 in the Upper Thames.

[b] Testing was completed using Pearson's chi-square tests for binary or categorical data (Fisher's exact test was used if a cell count less than 5) and Wilcoxon / Mann-Whitney tests for continuous data.

B5.2 Modelling Results

The parameters estimated for the three additional specifications (Table B6) are similar to those in of the main text (Table 3.5). The only notable difference is that the 'Recognition × Wetland' element of the lower triangular Cholesky matrix is insignificant for the Upper Thames in the models presented in Table A5, while it is significant for the corresponding model in the main text. The parameters for the models with all demographic interactions are also very similar to those for the models with significant demographic interactions. Since the parameters are largely the same we do not repeat their interpretation here. In terms of interactions, only a single interaction with the ASC is significant for the Upper Thames watershed (age). This suggests that older individuals have a lower mean parameter for the ASC (essentially, older individuals are willing to accept more for enrolling land in the program all else equal). Three such interactions are significant for the Grand watershed (female gender, age, and having a post-secondary education). These interactions indicate that older respondents, female respondents, and those with a post-secondary education have a lower mean parameter for the ASC and are willing to accept less compensation all else equal. Aside from the mean ASC parameter and associated interactions the model parameters with and without demographic interactions appear similar. For both watersheds, the McFadden's pseudo R^2 suggests that the two models with demographic interactions appear to fit the data similarly well and both slightly better than the model without interactions. Similarly, in the case of the Grand watershed the AIC suggests that the model with all demographic interactions is more parsimonious than the model without interactions. Although, the AIC suggests the opposite for the Upper Thames watershed as does the more stringent BIC for both watersheds. However, according to both information criteria the model with significant interactions only is the most parsimonious in the case of the Grand, while the AIC suggests that this model is the most parsimonious of the models estimated using the Upper Thames data (though not the BIC).

Table B6: Models in Willingness to Accept Space for the Models with and without Demographic Interactions

Variables	No Interactions		All Interactions		Significant Interactions	
	Grand	U. Thames	Grand	U. Thames	Grand	U. Thames
Mean[a]						
ASC × Female			3.7789***	-1.2009	3.3148**	
			(1.4508)	(1.4831)	(1.6524)	
ASC × Age			0.1375***	-0.1082**	0.1026**	-0.1005**
			(0.0495)	(0.0445)	(0.0433)	(0.0496)
ASC × Post-secondary			4.6705***	0.5498	4.7439***	
			(1.213)	(1.1378)	(1.3341)	
ASC × Employed			2.2126	-0.2593		
			(1.6617)	(1.4015)		
ASC × Median Income			-0.6215	-0.8548		
			(1.1716)	(1.0761)		
ASC	0.6368	0.8901	-11.1186***	7.9092**	-7.7712***	6.7110**
	(0.7739)	(0.8832)	(3.5079)	(3.2695)	(2.4185)	(3.0745)
Acres	-0.2170**	-0.3450***	-0.2097*	-0.3663***	-0.2075*	-0.3534***
	(0.1087)	(0.1078)	(0.1081)	(0.1077)	(0.1085)	(0.1073)
Land Type (productive)	-2.3855***	-2.1010***	-2.3838***	-2.0891***	-2.3714***	-2.0513***
	(0.2691)	(0.2415)	(0.2662)	(0.2316)	(0.2667)	(0.2243)
Activity: Wetland	-1.0229***	-1.0042***	-1.0159***	-0.9874***	-1.0255***	-0.9946***
	(0.2726)	(0.2524)	(0.2696)	(0.2466)	(0.2713)	(0.2445)
Activity: Trees	1.2395***	1.1695***	1.2485***	1.1411***	1.2574***	1.1452***
	(0.2586)	(0.2276)	(0.2575)	(0.2267)	(0.2578)	(0.2243)
Recognition (yes)	-0.9347***	-0.0108	-0.8431**	0.0153	-0.8500**	-0.0099
	(0.3347)	(0.3229)	(0.3344)	(0.2949)	(0.3370)	(0.2968)
Elements of the Lower Triangular Cholesky Matrix						
ASC × ASC	9.1847***	8.2987***	8.8638***	8.1295***	8.8675***	8.0916***
	(1.0829)	(1.0947)	(1.0642)	(0.9749)	(1.0676)	(1.0067)
Acres × ASC	-0.0196	-0.1664	-0.0893	-0.1965	-0.1099	-0.1634
	(0.1733)	(0.1590)	(0.1732)	(0.1575)	(0.1778)	(0.1625)

Variables	No Interactions		All Interactions		Significant Interactions	
	Grand	U. Thames	Grand	U. Thames	Grand	U. Thames
Land Type × ASC	0.2906	0.1388	0.2529	-0.0197	0.2031	-0.0251
	(0.3466)	(0.2914)	(0.3420)	(0.2843)	(0.3477)	(0.3160)
Wetland × ASC	0.0928	-0.0495	0.0122	-0.1321	0.0568	-0.0788
	(0.3890)	(0.3702)	(0.3760)	(0.3275)	(0.3802)	(0.3588)
Trees × ASC	-0.1618	0.1935	-0.0896	0.3069	-0.1137	0.2912
	(0.3708)	(0.3247)	(0.3640)	(0.3075)	(0.3667)	(0.3287)
Recognition × ASC	0.6044	0.0334	0.2644	0.0862	0.2370	0.0635
	(0.4637)	(0.4428)	(0.4551)	(0.4079)	(0.4535)	(0.4266)
Acres × Acres	-0.9384***	-0.6763***	-0.8781***	-0.7027***	-0.8963***	-0.7028***
	(0.1639)	(0.1300)	(0.1698)	(0.1160)	(0.1745)	(0.1272)
Land Type × Acres	-0.8041*	-0.1149	-0.8576*	-0.3539	-0.8657*	-0.2190
	(0.4223)	(0.5588)	(0.5020)	(0.3380)	(0.5261)	(0.4600)
Wetland × Acres	-0.0843	-0.8512**	-0.0110	-0.9865***	0.0122	-0.9501**
	(0.4914)	(0.4282)	(0.5038)	(0.3736)	(0.5010)	(0.4048)
Trees × Acres	0.2016	0.4627	0.1971	0.5192	0.1857	0.4985
	(0.4441)	(0.3934)	(0.4560)	(0.3865)	(0.4574)	(0.3581)
Recognition × Acres	0.3682	-0.0439	0.4106	-0.1489	0.3831	-0.1028
	(0.5555)	(0.5524)	(0.6391)	(0.4431)	(0.6398)	(0.5020)
Land Type × Land Type	-2.5797***	1.8091***	-2.5273***	1.7328***	-2.5125***	1.7609***
	(0.3259)	(0.2765)	(0.3225)	(0.2528)	(0.3239)	(0.2528)
Wetland × Land Type	0.9192**	-0.4093	0.9127**	-0.5123	0.8969**	-0.4364
	(0.3662)	(0.3620)	(0.3675)	(0.3582)	(0.3674)	(0.3550)
Trees × Land Type	-0.1564	-0.1299	-0.1458	-0.0327	-0.1348	-0.0719
	(0.3436)	(0.3408)	(0.3485)	(0.3484)	(0.3533)	(0.3237)
Recognition × Land Type	0.8387*	0.2680	0.7264	0.1979	0.7119	0.2334
	(0.4574)	(0.5567)	(0.4614)	(0.4264)	(0.4571)	(0.4388)
Wetland × Wetland	-2.6484***	1.6876***	-2.6057***	1.6425***	-2.6154***	1.6838***
	(0.3651)	(0.3356)	(0.357)	(0.3613)	(0.3589)	(0.3287)
Trees × Wetland	1.4302***	-0.4843	1.4168***	-0.3799	1.4116***	-0.4784
	(0.3674)	(0.4100)	(0.3773)	(0.5396)	(0.3800)	(0.4042)
Recognition × Wetland	0.3555	0.8014	0.3515	0.7609	0.3471	0.8257
	(0.5114)	(0.5330)	(0.4811)	(0.5266)	(0.4961)	(0.5033)

Variables	No Interactions		All Interactions		Significant Interactions	
	Grand	U. Thames	Grand	U. Thames	Grand	U. Thames
Trees × Trees	2.0661***	1.1069***	2.0522***	1.0568***	2.0494***	1.0710***
	(0.2994)	(0.3138)	(0.3008)	(0.3733)	(0.3010)	(0.3073)
Recognition × Trees	0.1441	-0.1964	0.0369	-0.2543	0.0186	-0.1979
	(0.5155)	(0.5153)	(0.4931)	(0.5347)	(0.4864)	(0.5149)
Recognition × Recognition	-2.2739***	1.6800***	-2.3070***	1.7276***	-2.3472***	1.6900***
	(0.4584)	(0.4406)	(0.4427)	(0.3626)	(0.4365)	(0.3925)
Scale						
Constant (θ)	-0.7211***	-0.3123	-0.6833***	-0.1323	-0.7091***	-0.2267
	(0.1658)	(0.3236)	(0.183)	(0.4315)	(0.1648)	(0.3805)
Tau (τ)	0.1999	0.5825	0.3157	0.7574*	0.2537	0.6593*
	(0.3735)	(0.3690)	(0.2985)	(0.3918)	(0.3095)	(0.3758)
Model Statistics						
Observations	8550	5661	8550	5661	8550	5661
Log-likelihood	-1607.67	-1028.95	-1590.64	-1026.11	-1591.48	-1027.04
Pseudo R2	0.28	0.29	0.29	0.30	0.29	0.30
AIC (BIC)	3273.35	2115.89	3249.28	2120.23	3246.96	2114.09
	(3477.90)	(2308.49)	(3489.11)	(2346.04)	(3472.68)	(2313.33)

[a] Coefficients represent the negative of WTA values scaled by 100 since the payment attribute was divided by 100 to aid model convergence. Standard errors appear in brackets below the corresponding coefficient.

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

The outcome of the Swait & Louviere (1993) tests are the same for the models with and without all demographic interactions (Table A7).[71] In both cases the tests indicate that models estimated for the Grand and Upper Thames watersheds do not differ significantly. The first likelihood ratio tests fail to reject the null hypothesis of equal model parameters for the model with all demographic interactions $\left(X^2_{(34)} = 40.90 \text{ and corresponding p} - \text{value} = 0.19\right)$ and the model without demographic interactions $\left(X^2_{(29)} = 25.23 \text{ and corresponding p} - \text{value} = 0.66\right)$. Furthermore, the second likelihood ratio test also fails to reject the null hypothesis of equal scale parameters for the model with all demographic interactions $\left(X^2_{(1)} = 0.10 \text{ and corresponding p} - \text{value} = 0.75\right)$ and the model without demographic interactions $\left(X^2_{(1)} = 0.11 \text{ and corresponding p} - \text{value} = 0.75\right)$ which corroborates the insignificance of the parameters accounting for different scales in the initial pooled models ("Pooled 1"). Though the specifics differ somewhat, the outcomes of these Swait & Louviere (1993) tests are the same as those in the main text.

[71] We do not compare the model with significant demographic interactions with any of the other models using this test.

Table B7: Pooled Models in Willingness to Accept Space Serving as Inputs into the Swait and Louviere Test

Variables	No Interactions		Demographic Interactions	
	Pooled 1	Pooled 2	Pooled 1	Pooled 2
Mean[a]				
ASC × Female			1.8656*	1.8674*
			(1.1035)	(1.1076)
ASC × Age			0.0502	0.0503
			(0.0361)	(0.0361)
ASC × Post-secondary			3.5402***	3.5451***
			(0.8958)	(0.8960)
ASC × Employed			0.8304	0.8419
			(1.3410)	(1.3417)
ASC × Median Income			-0.9195	-0.9184
			(0.8562)	(0.8556)
ASC	0.6850	0.6851	-4.4486	-4.4653
	(0.5540)	(0.5542)	(2.8416)	(2.8449)
Acres	-0.2634***	-0.2628***	-0.2591***	-0.2584***
	(0.0763)	(0.0763)	(0.0770)	(0.0770)
Land Type (productive)	-2.2291***	-2.2300***	-2.2256***	-2.2269***
	(0.1779)	(0.1780)	(0.1764)	(0.1765)
Activity: Wetland	-1.0024***	-1.0023***	-0.9977***	-0.9976***
	(0.1848)	(0.1849)	(0.1849)	(0.1851)
Activity: Trees	1.1769***	1.1769***	1.1878***	1.1887***
	(0.1741)	(0.1742)	(0.1752)	(0.1755)
Recognition (yes)	-0.5269**	-0.5299**	-0.4901**	-0.4938**
	(0.2233)	(0.2233)	(0.2215)	(0.2216)
Elements of the Lower Triangular Cholesky Matrix				
ASC × ASC	8.6896***	8.6916***	8.5968***	8.5986***
	(0.7485)	(0.7485)	(0.7489)	(0.7493)
Acres × ASC	-0.0952	-0.0961	-0.1513	-0.1517
	(0.1192)	(0.1189)	(0.1267)	(0.1265)
Land Type × ASC	0.2761	0.2758	0.2134	0.2126
	(0.2365)	(0.2361)	(0.2492)	(0.2494)
Wetland × ASC	-0.0423	-0.0397	-0.0843	-0.0808
	(0.2666)	(0.2665)	(0.2729)	(0.2728)
Trees × ASC	0.0738	0.0722	0.0718	0.0690
	(0.2533)	(0.2532)	(0.2527)	(0.2525)
Recognition × ASC	0.3138	0.3137	0.1228	0.1226
	(0.3214)	(0.3217)	(0.3252)	(0.3254)
Acres × Acres	-0.8140***	-0.8160***	-0.8069***	-0.8087***
	(0.1111)	(0.1108)	(0.1153)	(0.1157)
Land Type × Acres	-0.3004	-0.3083	-0.3372	-0.3427
	(0.3221)	(0.3222)	(0.3385)	(0.3387)
Wetland × Acres	-0.5432	-0.5397	-0.5523	-0.5493
	(0.3503)	(0.3511)	(0.3523)	(0.3521)
Trees × Acres	0.4253	0.4263	0.4048	0.4047
	(0.3422)	(0.3422)	(0.3376)	(0.3370)

Variables	No Interactions		Demographic Interactions	
	Pooled 1	**Pooled 2**	**Pooled 1**	**Pooled 2**
Recognition × Acres	0.1227	0.1204	0.0972	0.0962
	(0.4315)	(0.4315)	(0.4197)	(0.4194)
Land Type × Land Type	-2.2186***	-2.2201***	-2.2240***	-2.2268***
	(0.2120)	(0.2123)	(0.2136)	(0.2137)
Wetland × Land Type	0.6880***	0.6866***	0.6676**	0.6674**
	(0.2613)	(0.2617)	(0.2712)	(0.2712)
Trees × Land Type	0.0259	0.0244	0.0378	0.0374
	(0.2476)	(0.2478)	(0.2533)	(0.2534)
Recognition × Land Type	0.4040	0.4150	0.3615	0.3669
	(0.3447)	(0.3431)	(0.3416)	(0.3413)
Wetland × Wetland	2.2274***	2.2329***	2.2410***	2.2488***
	(0.2471)	(0.2461)	(0.2470)	(0.2453)
Trees × Wetland	-1.0197***	-1.0237***	-1.0415***	-1.0500***
	(0.2723)	(0.2707)	(0.2677)	(0.2653)
Recognition × Wetland	0.3006	0.2937	0.3024	0.2970
	(0.3552)	(0.3523)	(0.3551)	(0.3534)
Trees × Trees	1.6983***	1.7007***	1.7192***	1.7222***
	(0.1978)	(0.1971)	(0.1988)	(0.1983)
Recognition × Trees	-0.0770	-0.0787	-0.0636	-0.0639
	(0.3495)	(0.3477)	(0.3434)	(0.3424)
Recognition × Recognition	-2.0889***	-2.0927***	-2.1239***	-2.1296***
	(0.2966)	(0.2959)	(0.2936)	(0.2928)
Scale				
Constant (θ)	-0.6025***	-0.6217***	-0.6070***	-0.6292***
	(0.1570)	(0.1443)	(0.1490)	(0.1303)
Grand dataset indicator	-0.0373		-0.0370	
	(0.1150)		(0.1145)	
Tau (τ)	0.2490	0.2564	0.2316	0.2317
	(0.2769)	(0.2696)	(0.2575)	(0.2559)
Model Statistics				
Observations	14,211		14,211	
Log-likelihood	-2649.24	-2649.29	-2637.20	-2637.25

[a] Coefficients represent the negative of WTA values scaled by 100 since the payment attribute was divided by 100 to aid model convergence. Standard errors appear in brackets below the corresponding coefficient.

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

B5.3 Willingness to Accept, Transfer Errors, and Testing

B5.3.1 Marginal Willingness to Accept

The marginal willingness to accept (WTA) estimates derived from the model without demographic interactions in this appendix (Table B8) are not substantially different from those estimated for the main text (Table 3.6). While the errors and tolerance levels are broadly similar as well, these values are generally a lower for the model without interactions in this appendix. However, there are exceptions – notably the error and tolerance level values observed for public recognition derived from the model without interactions in this appendix are much larger than the values in the main text. Finally, the outcomes of the complete combinatorial tests are the same (at the 95% level of significance).

Comparing the results for the models without and with demographic interactions generates a narrative similar to that in the previous paragraph (Tables B8, B9, and B10). Differences in marginal WTA are observed, though for the most part they are not substantial. Similarly, transfer errors and tolerance levels resulting from the model without demographic interaction are generally a little lower than those resulting from the models with demographic interactions (as evidenced by the medians since the means are influenced by certain very large errors or tolerance levels). Clear exceptions are observed when transferring WTA estimates for public recognition to the Upper Thames — substantially larger errors and tolerance levels result from the model without interactions for public recognition relative to the model with all demographic interactions (though not for the reduced specification with significant interactions only). Another notable exception is observed for transfers of WTA values elicited for the ASC term. Though the transfer errors observed for the models with demographic interactions are somewhat larger than those observed for the model without interactions, the tolerance levels calculated for transfers of WTA for the ASC term derived from the interacted specifications are many times larger than those levels resulting from the non-interacted specification. This outcome reflects the higher variation in WTA for the ASC term observed to result from the model with demographic interactions. The difference in the width of the confidence intervals between Table A7 and Tables A8 or A90 makes this evident, and this reflects the difference in the standard deviations of these WTA estimates (they jump from 88.64 to 328.30 for the Upper Thames and 77.50 to 348.59

for the Grand). Dropping insignificant interaction variables does not change this finding substantially as the standard deviations are 304.94 for the Upper Thames and 240.47 for the Grand. Lastly, the three model specifications yield the same outcomes for the complete combinatorial test.

Table B8: Marginal WTA and Errors for Transfers Between Two Watersheds in Southern Ontario for the Model with No Demographic Interactions

Attribute	Marginal WTA (2013 CAD)[a]		Errors (%)				Testing			
								Tolerance Levels (%)[b]		
	Grand	Upper Thames	PS: Grand	PS: Thames	Mean Directional	Chatto-padhyay	CC	PS: Grand	PS: Thames	Mean Tolerance (%)
ASC	-88.21 (-240.64 to 61.63)	-111.59 (-286.1 to 59.51)	27	21	24	23	0.42	247	195	221
Acres	17.57 (-3.53 to 38.38)	30.59 (10.08 to 50.84)	74	43	58	54	0.20	216	124	170
Land Type										
Productive (effects)	232.13 (177.13 to 283.96)	207.46 (156.81 to 255.08)	11	12	11	11	0.25	37	41	39
Marginal (effects)	-232.13 (-283.96 to -177.13)	-207.46 (-255.08 to -156.81)	11	12	11	11	0.25	37	41	39
Marginal to productive	464.27 (354.26 to 567.91)	414.92 (313.62 to 510.16)	11	12	11	11	0.25	37	41	39
Activity										
Wetland (effects)	104.97 (50.94 to 160.16)	104.45 (54.72 to 155.56)	0	0	0	0	0.50	61	61	61
Trees (effects)	-118.47 (-168.19 to -66.63)	-114.59 (-158.5 to -69)	3	3	3	3	0.46	52	54	53
Meadow (effects)	13.50 (-34.53 to 63.38)	10.14 (-34.37 to 56.50)	25	33	29	28	0.46	439	584	512
Meadow to trees	-135.65 (-222.62 to -50.92)	-124.73 (-199.67 to -51.30)	8	9	8	8	0.45	77	82	80

Attribute	Marginal WTA (2013 CAD)[a]		Errors (%)				Testing			
								Tolerance Levels (%)[b]		
	Grand	Upper Thames	PS: Grand	PS: Thames	Mean Directional	Chatto-padhyay	CC	PS: Grand	PS: Thames	Mean Tolerance (%)
Meadow to wetland	83.87 (-4.38 to 174.82)	90.12 (5.79 to 175.49)	7	7	7	7	0.48	117	113	115
Trees to wetland	223.44 (130.55 to 317.12)	219.03 (135.06 to 305.01)	2	2	2	2	0.47	50	51	51
Recognition (yes vs. no)	92.74 (28.22 to 159.25)	-0.30 (-63.66 to 63.83)	100	31,522	15,811	201	0.02**	184	58,000	29,092
Mean (Median) Error or Tolerance (%)										
Includes effects coded estimates			31 (18)	3956 (16)	1994 (16)	42 (17)		159 (123)	7388 (93)	3773 (93)
Includes change coded estimates			33 (11)	4516 (12)	2275 (11)	44 (11)		133 (117)	8372 (113)	4252 (115)

[a] 95% confidence intervals, estimated via the Krinsky-Robb method with 4000 draws, appear in brackets below each implicit price

[b] The tolerance levels represent the threshold at which the pairs of estimates are deemed equivalent at the 95% level of significance.

*, **, and *** indicate that the CC test finds the pair of implicit prices to be *different* at the 90%, 95%, and 99% levels of significance, respectively

Table B9: Marginal WTA and Errors for Transfers Between Two Watersheds in Southern Ontario for the Model with *All* Demographic Interactions

Attribute	Marginal WTA (2013 CAD)[a]		Errors (%)				Testing			
	Grand	Upper Thames	PS: Grand	PS: Thames	Mean Directional	Chatto-padhyay	CC	Tolerance Levels (%)[b] PS: Grand	Tolerance Levels (%)[b] PS: Thames	Mean Tolerance (%)
ASC	-82.86 (-771.72 to 610.72)	-129.24 (-778.30 to 528.78)	56	36	46	44	0.46	1007	646	827
Acres	16.88 (-4.07 to 38.36)	32.68 (11.82 to 53.35)	94	48	71	64	0.15	242	125	184
Land Type										
Productive (effects)	232.84 (179.32 to 282.49)	206.92 (160.91 to 252.06)	11	13	12	12	0.23	36	41	39
Marginal (effects)	-232.84 (-282.49 to -179.32)	-206.92 (-252.06 to -160.91)	11	13	12	12	0.23	36	41	39
Marginal to productive	465.69 (358.65 to 564.98)	413.83 (321.82 to 504.12)	11	13	12	12	0.23	36	41	39
Activity										
Wetland (effects)	104.90 (51.22 to 158.44)	103.57 (53.28 to 152.64)	1	1	1	1	0.49	60	61	61
Trees (effects)	-119.85 (-170.38 to -69.29)	-112.14 (-155.75 to -67.64)	6	7	7	7	0.41	54	58	56
Meadow (effects)	14.95 (-33.07 to 63.21)	8.57 (-34.67 to 51.36)	43	74	58	54	0.42	408	711	560
Meadow to trees	-134.79 (-215.63 to -50.72)	-120.71 (-191.91 to -47.52)	10	12	11	11	0.40	80	89	85

Attribute	Marginal WTA (2013 CAD)[a]		Errors (%)				Testing			
	Grand	Upper Thames	PS: Grand	PS: Thames	Mean Directional	Chatto-padhyay	CC	Tolerance Levels (%)[b] PS: Grand	Tolerance Levels (%)[b] PS: Thames	Mean Tolerance (%)
Meadow to wetland	89.95 (2.06 to 180.28)	95.00 (15.17 to 175.61)	6	5	5	5	0.47	118	111	115
Trees to wetland	224.74 (132.38 to 317.51)	215.71 (131.38 to 299.55)	4	4	4	4	0.44	51	53	52
Recognition (yes vs. no)	84.38 (18.90 to 149.49)	-2.50 (-60.17 to 53.93)	103	3473	1788	212	0.03**	191	6412	3302
Mean (Median) Error or Tolerance (%)										
Includes effects coded estimates			41 (27)	458 (24)	51 (28)	249 (24)		254 (126)	1012 (93)	633 (93)
Includes change coded estimates			41 (11)	513 (13)	50 (12)	277 (12)		246 (118)	1068 (111)	657 (115)

[a] 95% confidence intervals, estimated via the Krinsky-Robb method with 4000 draws, appear in brackets below each implicit price

[b] The tolerance levels represent the threshold at which the pairs of estimates are deemed equivalent at the 95% level of significance.

*, **, and *** indicate that the CC test finds the pair of implicit prices to be *different* at the 90%, 95%, and 99% levels of significance, respectively

Table B10: Marginal WTA and Errors for Transfers Between Two Watersheds in Southern Ontario for the Model with *Significant* Demographic Interactions

Attribute	Marginal WTA (2013 CAD)[a]		Errors (%)				Testing			
								Tolerance Levels (%)[b]		
	Grand	Upper Thames	PS: Grand	PS: Thames	Mean Directional	Chatto-padhyay	CC	PS: Grand	PS: Thames	Mean Tolerance (%)
ASC	-80.81 (-551.52 to 391.05)	-118.45 (-714.49 to 487.84)	47	32	39	38	0.46	836	571	704
Acres	16.84 (-4.50 to 38.24)	31.38 (10.97 to 51.94)	86	46	66	60	0.17	235	126	181
Land Type										
Productive (effects)	231.20 (179.19 to 283.75)	203.13 (159.33 to 247.38)	12	14	13	13	0.21	38	43	41
Marginal (effects)	-231.20 (-283.75 to -179.19)	-203.13 (-247.38 to -159.33)	12	14	13	13	0.21	38	43	41
Marginal to productive	462.40 (358.38 to 567.5)	406.25 (318.66 to 494.76)	12	14	13	13	0.21	38	43	41
Activity										
Wetland (effects)	105.36 (50.40 to 159.56)	104.42 (55.38 to 153.79)	1	1	1	1	0.49	60	60	60
Trees (effects)	-120.63 (-171.12 to -71.1)	-113.39 (-158.02 to -68.18)	6	6	6	6	0.42	53	56	55
Meadow (effects)	15.26 (-33.60 to 63.31)	8.97 (-33.83 to 51.74)	41	70	56	52	0.43	400	680	540
Meadow to trees	-135.89 (-217.35 to -55.63)	-121.50 (-194.23 to -48.30)	11	12	11	11	0.41	78	87	83

Attribute	Marginal WTA (2013 CAD)[a] Grand	Marginal WTA (2013 CAD)[a] Upper Thames	Errors (%) PS: Grand	Errors (%) PS: Thames	Errors (%) Mean Directional	Errors (%) Chatto-padhyay	Testing CC	Testing Tolerance Levels (%)[b] PS: Grand	Testing Tolerance Levels (%)[b] PS: Thames	Testing Mean Tolerance (%)
Meadow to wetland	82.42 (-8.80 to 173.15)	91.27 (9.62 to 172.09)	11	10	10	10	0.47	120	113	117
Trees to wetland	225.99 (134.20 to 319.94)	217.82 (134.39 to 301.83)	4	4	4	4	0.45	50	52	51
Recognition (yes vs. no)	85.09 (19.97 to 150.55)	0.17 (-58.44 to 58.96)	100	48,742	24421	199	0.03**	188	91,000	45,594
Mean (Median) Error or Tolerance (%)										
Includes effects coded estimates			38 (27)	6116 (23)	3077 (23)	48 (25)		231 (124)	11,572 (93)	5902 (93)
Includes change coded estimates			39 (12)	6980 (14)	3509 (13)	48 (13)		221 (120)	13,142 (113)	6681 (117)

[a] 95% confidence intervals, estimated via the Krinsky-Robb method with 4000 draws, appear in brackets below each implicit price

[b] The tolerance levels represent the threshold at which the pairs of estimates are deemed equivalent at the 95% level of significance.

*, **, and *** indicate that the CC test finds the pair of implicit prices to be *different* at the 90%, 95%, and 99% levels of significance, respectively

B5.3.2 Compensating Surplus

The compensating surplus (CS) estimates derived from the model without demographic interactions (Figure B2a) follow a trend similar to that of the CS estimates presented in the main text (Figure 3.2). Additionally, the estimates derived from the model without interactions appear quite similar to those estimated from the models with demographic interactions (Figures B2b and B2c).

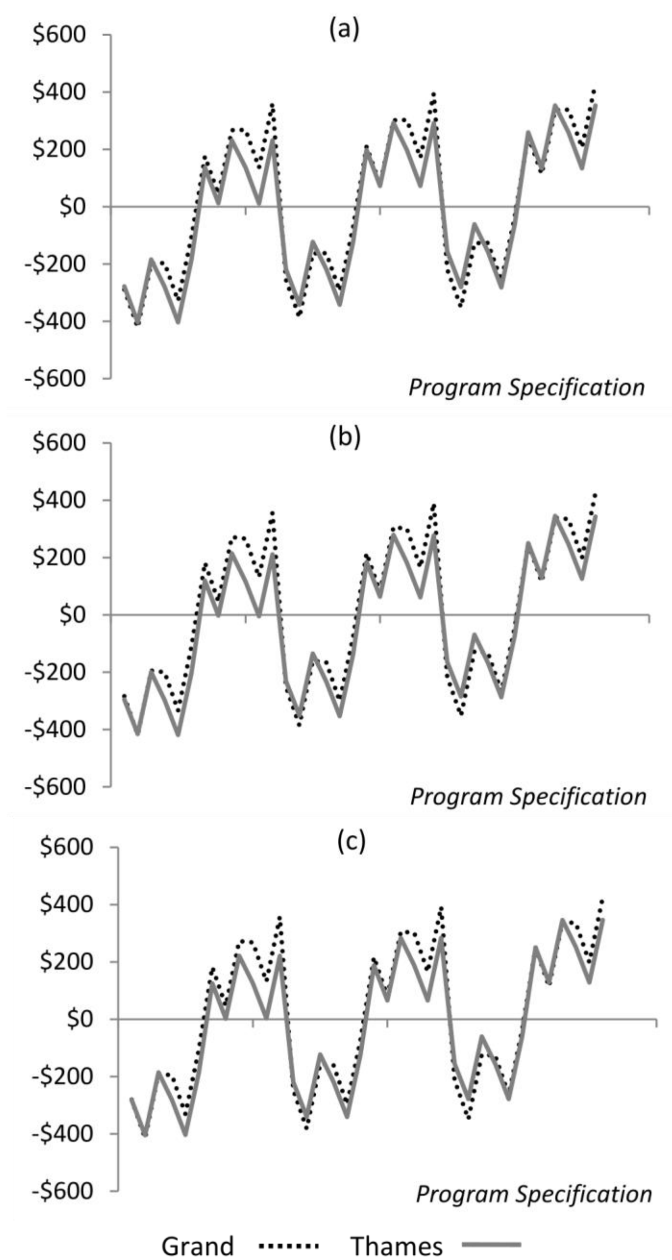

Figure B2: Compensating Surplus Estimates for All Possible Program Specifications by Watershed for the Models without Interactions (a), with all Demographic Interactions (b), and with Significant Demographic Interactions (c)

Comparing transfer results for the model without interactions in this appendix (Table B11 and Figure B3) with those results for the model without interactions in the main text (Table 3.7 and Figure 3.3) reveals that the latter yields modestly higher transfer errors, in general, though the tolerance levels derived from this model are a little lower according to the median values (the means indicate the opposite in terms of tolerance levels). Transfers of values resulting from both of these models are generally marginally larger when the Upper Thames is treated as the policy site relative to when the policy site is the Grand. Additionally, the outcomes of the complete combinatorial tests are nearly identical (though two pairs of estimates differ significantly at the 10% level in the analysis completed as part of the main text compared to no significantly different pairs in the assessment presented in this appendix). In sum, the validity and reliability of transfers based on these two models are fairly similar.

Table B11: Summary of Errors, Tolerance Levels, and Complete Combinatorial Tests for Transfers of Compensating Surplus Between Two Southern Ontario Watersheds

Transfer	Transfer Errors (%)				Tolerance Levels (%)				CC (Different Pairs)
	Mean	Median	Low	High	Mean	Median	Low	High	
Model without Demographic Interactions									
Directional									
Grand to U. Thames	67	25	3	1073	275	122	60	2839	N/A
U. Thames to Grand	30	23	3	91	158	106	59	688	
Non-Directional									
Grand and U. Thames	34	23	3	169		N/A			0*, 0**, 0***
Model with All Demographic Interactions									
Directional									
Grand to U. Thames	197	27	0	3168	2395	416	191	47,000	N/A
U. Thames to Grand	32	25	0	104	506	367	190	1927	
Non-Directional									
Grand and U. Thames	39	24	0	216		N/A			0*, 0**, 0***
Model with Significant Demographic Interactions									
Directional									
Grand to U. Thames	203	26	0	4542	1876	352	162	27,000	N/A
U. Thames to Grand	30	22	0	98	426	303	157	1762	
Non-Directional									
Grand and U. Thames	37	23	0	192		N/A			0*, 0**, 0***

*, **, and *** indicate the number of pairs of compensating surplus estimates the CC test finds *different* at the 90%, 95%, and 99% levels of significance, respectively

Given the similarity in CS estimates observed to result from the three model specifications (Figure B2) it is not surprising that the transfer errors are fairly similar overall as evidenced by the median values in Table B11 (certain large errors skew the mean) and distributions illustrated in Figure B3. However, there is a notable difference in tolerance levels across the models with and without interactions even when looking at the median (which limits the influence of outliers). Tolerance levels are clearly larger for transfers of CS estimates derived from the interacted specifications than transfers of these estimates derived from the non-interacted specification. The divergent tolerance levels likely result from the fact that WTA for the ASC term derived from the models with demographic interactions is more variable than it is when estimated from the model without such interactions (as observed in Tables B8 to B10). Indeed, the mean of the standard deviation of the CS estimates is 323.40 for the Upper Thames and 351.26 for the Grand for the model with interactions, while the standard deviations are 90.84 for the Upper Thames and 83.44 for the Grand for the models without interactions. Dropping insignificant interactions reduces the standard deviations somewhat to 301.73 and 243.88 for the Upper Thames and Grand, respectively. In all cases these standard deviations are aligned with those of the marginal WTA for the ASC term. In addition, the influence of transfer direction is the same for all specifications, as transfers to the Upper Thames only result in slightly larger median errors and tolerance levels relative to transfers in the other direction for the three models. Finally, in terms of the complete combinatorial test, the three model specifications yield identical outcomes.

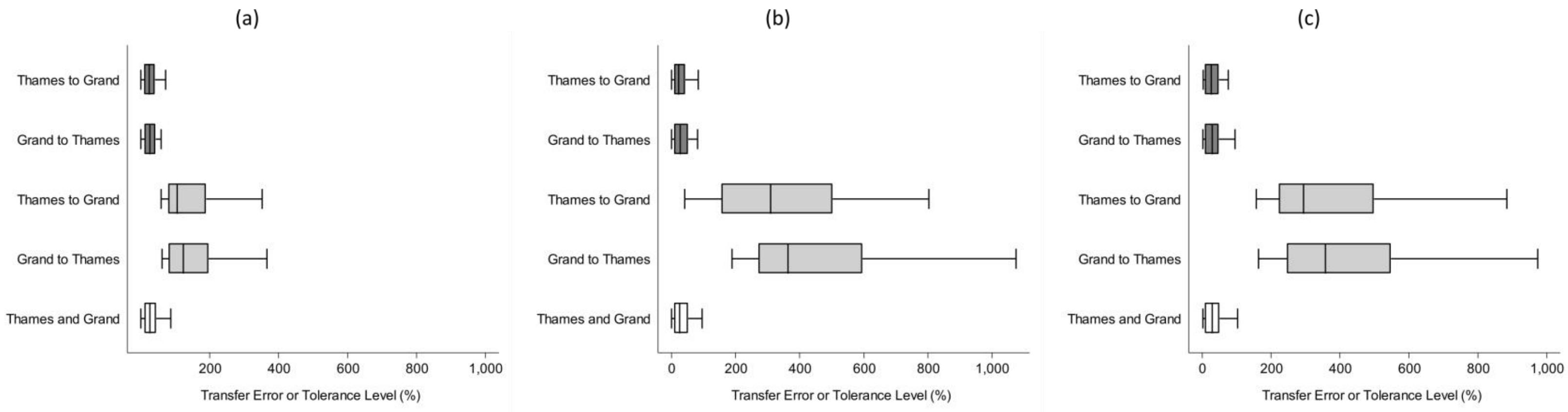

Figure A3: Box Plots of Transfer Errors and Tolerance Levels for the Model without Demographic Interactions (a), with All Demographic Interactions (b), and with Significant Demographic Interactions (c)[a, b]

Note: Outlier points are not plotted. Directional error boxes are dark grey, tolerance level boxes are light grey, and Chattopadhyay error boxes are white. In addition, the range of the x-axis for each panel differs from the range used for the boxplot in the main text, which has an upper limit of 300.

B5.3.3 Effect of Dropping Insignificant Demographic Interactions

Removing insignificant interaction variables has little effect on the parameters common to the model with all interactions (although we did not formally test the similarity of the two models). The marginal WTA and CS estimates are also similar across these two specifications. Likewise, although we observed slight improvements in accuracy there is little difference in the transfer errors resulting from this reduced model and the model with all demographic interactions. In addition, the two models yield identical outcomes for the complete combinatorial test. The issue motivating this extra model specification, the large tolerance levels observed to result for transfers of WTA for the ASC term and all the CS estimates, is still an issue for transfers based on the reduced specification with significant interactions only. However, the tolerance levels are slightly less as evidenced by Tables B10 and B11 as well as Figure B3.

B5.4 Conclusion

Overall, for the estimates derived from the model without interactions, the directional errors for transfers of marginal WTA range from 0% to 31,522% with a mean of 1331% and median of 11%, while these errors for transfers of CS range from 3% to 1073% with a mean of 48% and median of 24%. Non-directional Chattopadhyay errors for transfers of marginal WTA from this model range from 0% to 201% with a mean of 30% and median of 11%. These errors range from 3% to 169% for transfers of compensating surplus with a mean of 34% and median of 23%. For values elicited with this model, tolerance levels estimated for marginal WTA range from 37% to 58,000% with a mean of 2539% and median of 69%, while they range from 59% to 2839% for CS with a mean of 216% and median of 117%.

In terms of the estimates derived from the model with all demographic interactions, directional errors range from 1% to 3473% for transfers of marginal WTA with a mean of 169% and median of 11%, while they range from 0% to 3168% for transfers of CS with a mean of 115% and median of 26%. The corresponding non-directional errors for transfers of marginal WTA range from 1% to 212% with a mean of 36% and median of 12%, while these errors range from 0% to 216% for transfers of CS with a mean of 39% and median of 24%. The tolerance levels estimated from this model for marginal WTA range from 36% to 6412% with a mean of 446% and median of 71%, and range from 190% to 47,000% with a mean of 1451% and median of 391% for compensating surplus.

For the model with significant demographic interactions only, directional errors range from 1% to 48,742% for transfers of marginal WTA with a mean of 2054% and median of 12%, while they range from 0% to 4542% for transfers of CS with a mean of 117% and median of 24%. The analogous non-directional errors range from 1% to 199% with a mean of 35% and median of 13% for transfers of marginal WTA %, while these errors range from 0% to 192% for transfers of CS with a mean of 37% and median of 23%. The related tolerance levels for marginal WTA range from 38% to 91,000% with a mean of 3959% and median of 69%, and range from 157% to 47,000% with a mean of 1151% and median of 322% for compensating surplus.

Outliers aside, the errors from these two model specifications are fairly similar, and not that different from those in the main text. Furthermore, most of the tolerance levels for transfers of marginal WTA are similar for these specifications too. However, the key difference between transfers based on the two model specifications is that the tolerance levels are clearly higher for transfers of CS values derived from the model with demographic interactions. These interactions clearly result in more inefficient CS estimates via inflated variance of WTA for the ASC term. Basing our validity and reliability assessment on a model with significant interactions only appears to reduce tolerance levels, but only slightly — the issue still remains.

References

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Kaul, S., Boyle, K. J., Kuminoff, N. V, Parmeter, C. F., & Pope, J. C. (2013). What can we learn from benefit transfer errors? Evidence from 20 years of research on convergent validity. *Journal of Environmental Economics and Management*, *66*(1), 90–104. http://doi.org/10.1016/j.jeem.2013.03.001

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Appendix C.

Supplementary Material for Chapter 4

C1. Potential Percentage Errors for Transfers of Predicted Participation Market Shares

Assuming transfers of predicted participation market shares that are non-zero integers yields 10,000 possible percentage transfer errors. These potential errors are clearly skewed toward zero as illustrated in Figure C1 below.

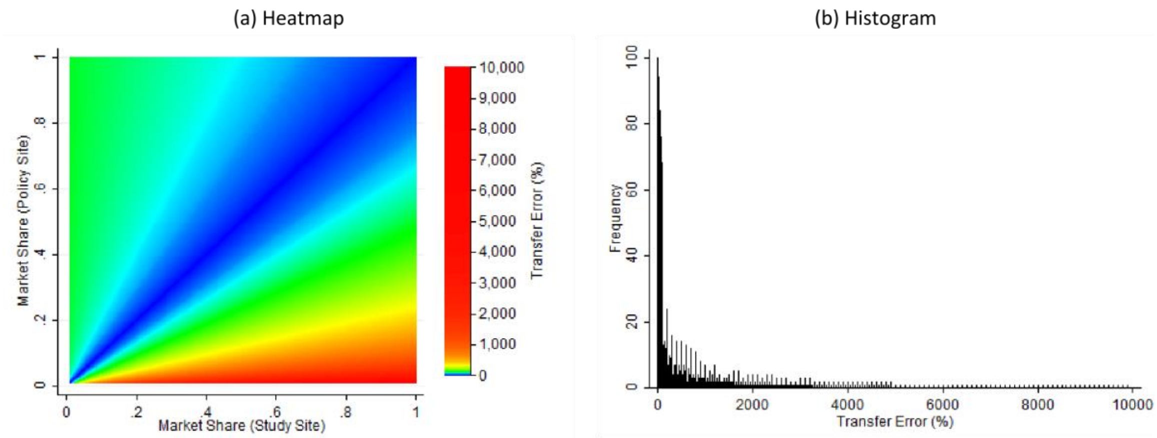

Figure C1: Distribution of Potential Percentage Errors for Transfers of Predicted Participation Market Shares

C2. The Choice Experiment

We have included a copy of the choice experiment's preamble and first choice set for reference.

Section 4: Incentives for Enhancing & Restoring Wetlands

Suppose that in an effort to enhance and restore wetlands within and adjacent to the Grand River watershed, the government offered a voluntary program that provided incentives to landowners to set aside some of their lands. The incentives would include public recognition, technical assistance, and/or annual payments to acknowledge their provision of an environmental service to society. The land could be converted from manicured lawns, old fields, or other to: (i) meadow or trees to help retain nearby wetlands; or (ii) wetlands if appropriate.

PROGRAM CONDITIONS:

Participating landowners would:

- Sign a 5-year contract to enroll some of their land and receive incentives (i.e., public recognition, technical assistance, and/or annual payments).
- Have the opportunity to renew the contract, or transfer/terminate it if the land is sold.
- Enroll land that is in addition to existing commitments under government or non-government programs and legal requirements.
- Have a say in what type of land conversion activities are implemented (i.e. whether to convert land to meadow, trees, or wetlands). All planting/restoration costs would be paid for by the government (on top of any financial incentive to you).

We would now like to ask you to evaluate several program options.

On each of the next few pages, you'll be presented with a set of 2 voluntary programs considered by the government. We ask you to choose between PROGRAM A, PROGRAM B, or NO PROGRAM.

PROGRAM CHARACTERISTICS:

Each program is described by the following range of PROGRAM CHARACTERISTICS:

Conversion activity	➡ land can be converted to Meadow, Trees, or Wetland
Number of acres	➡ area converted can be 0.5, 1, or 1.5 acres
Technical assistance	➡ can be Yes or No, depending on whether or not **technical experts** from the government or other groups are involved.
Public recognition	➡ can be Yes or No, depending on whether or not **signage** on property, stewardship **banquets**, & **awards** are provided.
Annual payments to you	➡ can be \$0 to \$250 per year (positive amounts acknowledge your provision of an environmental service to society).

Please consider the options carefully - as if you were entering into a real contract with the government - since the program would have a limited budget and could only fund a limited number of projects.

SET 1:

17a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Wetland	Meadow	---
Number of acres	1.5 acres	1 acre	---
Technical assistance	No	No	---
Public recognition	Yes	No	---
Annual payments to you	$200/year	$200/year	$0/year
Please choose only one	☐	☐	☐

17b. On a scale 1 to 10, how certain are you about the program choice you made above?
*Please circle the number that best represents your answer if **1 equals not at all certain** and **10 equals very certain**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

C3. Variance-Covariance Matrix and Standard Deviation Parameters

We generated each variance-covariance matrix (Σ) by multiplying the lower-triangular of the Cholesky matrix (L) by its transpose $(\Sigma = LL')$ using the 'mixlcov' command in Stata 12.1 (Hole, 2007). To generate the standard deviation parameters we squared each element of the lower-triangular of the Cholesky matrix, added the resulting values in each row, and then took the square root if this sum.

Table C1: Variance-Covariance Matrix and Standard Deviation Parameters Estimated from the Lower-Triangular of the Cholesky Matrix

	Variance-Covariance Matrix							Standard Deviation
	ASC	Acres	Wetland	Trees	Technical help (Yes)	Recognition (Yes)	ln(Annual payment)	
Grand River Watershed								
ASC	37.8621***							6.1532***
	(11.5283)							(0.9368)
Acres	6.3383**	4.5000***						2.1213***
	(2.6185)	(1.6804)						(0.3961)
Wetland	4.6354	1.3539	9.6376***					3.1045***
	(3.1542)	(1.0967)	(2.6312)					(0.4238)
Trees	-0.4707	-0.0005	-5.5930***	5.6662***				2.3804***
	(2.2350)	(0.7607)	(1.5825)	(1.5389)				(0.3232)
Technical help	-0.6342	-0.0377	0.4826	-1.2390*	1.4589*			1.2078***
(Yes)	(2.0616)	(0.7039)	(0.8356)	(0.7410)	(0.7684)			(0.3181)
Recognition (Yes)	-0.0051	-0.5794	-0.7634	-0.3830	0.1343	1.7708*		1.3307***
	(2.1661)	(0.7841)	(0.7941)	(0.6471)	(0.4379)	(0.9962)		(0.3743)
ln(Annual	0.4636	0.2574	0.4821	-0.3048	-0.8571**	-1.0561*	1.7771***	1.3331***
payment)	(0.7987)	(0.2746)	(0.3500)	(0.2674)	(0.3785)	(0.5456)	(0.4168)	(0.1563)
Upper Thames River Watershed								
ASC	30.6267***							5.5341***
	(9.1682)							(0.8283)

	Variance-Covariance Matrix							Standard Deviation
	ASC	**Acres**	**Wetland**	**Trees**	**Technical help (Yes)**	**Recognition (Yes)**	**ln(Annual payment)**	
Acres	3.2891	3.5766**						1.8912***
	(2.0972)	(1.5207)						(0.4021)
Wetland	-0.6112	0.6860	5.4788***					2.3407***
	(2.0331)	(0.7994)	(1.4737)					(0.3148)
Trees	3.8384*	0.1810	-2.9022***	4.3486***				2.0853***
	(2.2375)	(0.7249)	(0.8845)	(1.2629)				(0.3028)
Technical help	-0.5060	-1.4019	0.7786	-1.1340*	1.9347**			1.3909***
(Yes)	(1.9115)	(0.8558)	(0.6888)	(0.6516)	(0.9834)			(0.3535)
Recognition (Yes)	1.0239	0.4597	0.4607	-0.3439	0.1235	0.1789		0.4229*
	(1.5615)	(0.6008)	(0.5063)	(0.4545)	(0.3874)	(0.2164)		(0.2558)
ln(Annual	0.0477	-0.5813**	0.3385	0.4396	0.1011	-0.3228	1.9893***	1.4104***
payment)	(0.7841)	(0.2778)	(0.3420)	(0.3131)	(0.2429)	(0.4312)	(0.5340)	(0.1893)

*, **, and *** indicate that the estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

C4. Results for Mean of Mean Derivation Approach

We did not include the predicted participation market share and compensating surplus estimates generated via the ‘mean of mean’ approach and the ensuing transfer assessment in the main text since in many cases this approach yields unreasonably large CS estimates (see Figure C2 panel b). However, we did perform the transfer validity and reliability assessment using these CS and MS estimates as input and we have included these results as Appendix C4.

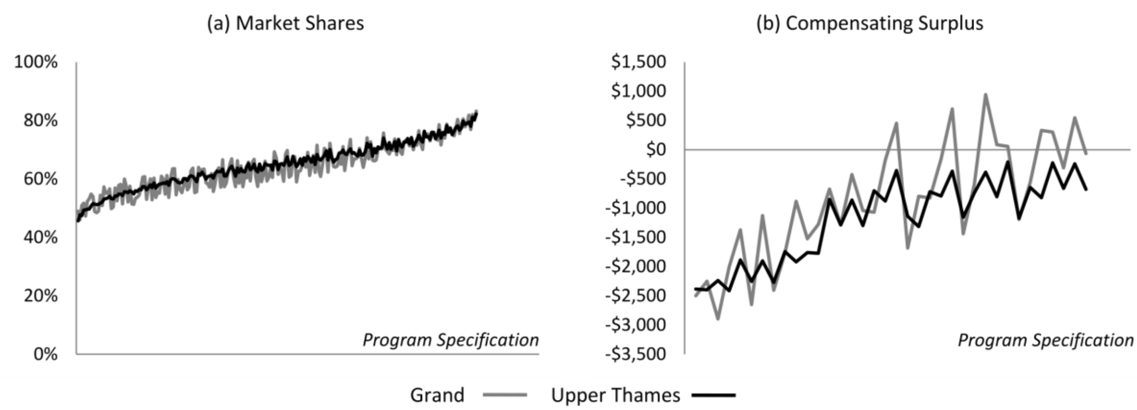

Figure C2: Market Share (a) and Compensating Surplus (b) Estimates
Note: For both panels the x-axis represents all possible program specifications (e.g., for panel (a) a point on this axis represents a program with 0.5 acres converted to wetlands with no technical help or recognition and a payment of $50, etc. and the points on this axis in panel (b) are similar though do not include a payment component.

As can be seen in Table C2 and Figure C3, the results are similar to those observed for the ‘mean of median’ derivation approach in that transfer errors and tolerance levels are much lower for predicted participation market shares compared to compensating surplus. However, transfers of estimates derived following the ‘mean of mean’ approach often yield lower transfer errors and tolerance levels relative to those resulting from the ‘mean of median’ approach. The results of the complete combinatorial tests are similar for the two approaches, however 6 pairs of market share estimates generated via the ‘mean of mean’ approach differ significantly at 10% while none of the pairs generated via the ‘mean of median’ approach significantly differed.

Table C2: Summary of Reliability and Validity Tests

Transfer	Transfer Errors (%)				Tolerance Levels (%)				Complete Combinatorial
	Mean	Median	Low	High	Mean	Median	Low	High	
Directional									
MS: Grand to Thames	4	3	0	9	15	15	7	25	N/A
MS: Thames to Grand	4	3	0	9	15	15	7	24	
CS: Grand to Thames	74	34	0	346	372	253	133	1298	
CS: Thames to Grand	144	36	0	1045	693	312	127	4173	
Non-Directional									
MS: Grand and Thames	4	3	0	9	N/A				6*, 0**, 0***
CS: Grand and Thames	187	36	0	1612					0*, 0**, 0***

*, **, and *** indicate the number of pairs of estimates that are different at the 90%, 95%, and 99% levels of significance, respectively

We can also see that transfer direction impacts transfers of the 'mean of mean' CS estimates with those to the Grand yielding a wider range of errors and tolerance levels relative to transfers in the other direction (Figure C3). Such a finding is not evident for the directional errors and tolerance levels calculated from the 'mean of median' estimates.

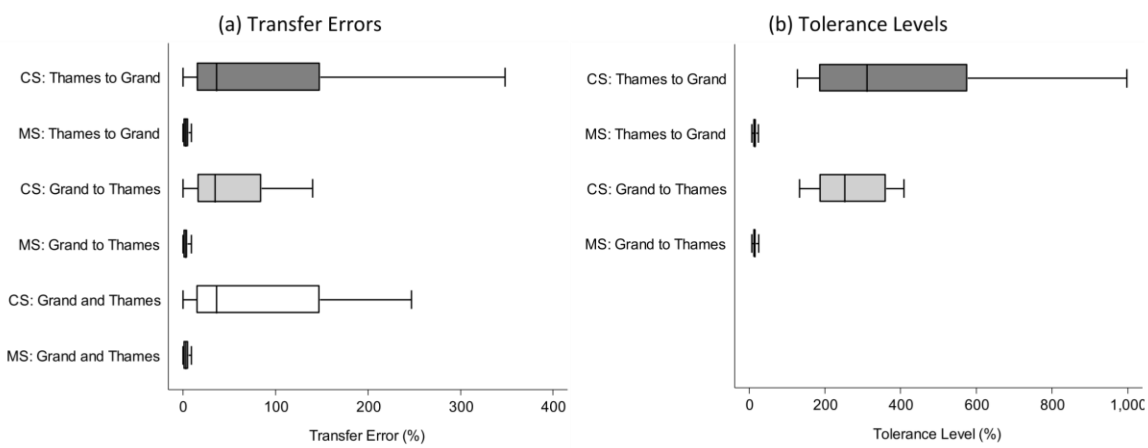

Figure C3: Boxplots of Transfer Errors and Tolerance Levels
Note: outliers not plotted; non-directional errors are white and directional errors are differing shades of grey.

The directional and non-directional errors levels calculated for compensating surplus derived via the 'mean of mean' approach are significantly larger for specifications involving larger areas and conversion of land to wetlands, and lower for specifications involving conversion to trees and technical help (Table C3). The relationships observed for the compensating surplus tolerance levels are similar, though the area conserved has no significant impact. For predicted participation market shares, directional and non-directional errors are significantly lower for specifications that involve converting land to trees, technical help, and higher payments. These errors are significantly higher for specifications that involve converting land to wetland. Predicted participation market share tolerance levels are lower for specifications that involve smaller areas, converting land to trees, technical help, no public recognition, and higher payments. Transfer direction only significantly impacts tolerance levels in the case of compensating surplus tolerance levels. These results suggest that compensating surplus and predicted participation market shares are differently impacted by transfer characteristics. In many cases these relationships are similar to those observed for transfers of the estimates derived via the ‘mean of median’ approach, with the notable exception of the impact of the conversion activity attribute on errors and tolerance levels.

Table C3: Regression of Errors and Tolerance Levels on Transfer Characteristics for Transfers Based on the "Mean of Mean" Approach[a]

Variable	Directional Errors		Tolerance Levels		Non-Directional Errors	
	MS	CS	MS	CS	MS	CS
Constant	0.8946***	3.5633***	2.6781***	5.8342***	0.8943***	3.7294***
	(0.0393)	(0.1544)	(0.0055)	(0.0622)	(0.0562)	(0.2252)
Area:	-0.0248	-0.5776***	-0.0164**	-0.1238	-0.0248	-0.5708*
0.5 ac	(0.0555)	(0.2184)	(0.0078)	(0.0879)	(0.0795)	(0.3185)
Area:	-0.0021	0.2024	-0.0162**	-0.0192	-0.0021	0.2454
1 ac	(0.0555)	(0.2184)	(0.0078)	(0.0879)	(0.0795)	(0.3185)
Area:	0.0269	0.3752*	0.0327***	0.1430	0.0269	0.3254
1.5 ac[b]	(0.0555)	(0.2184)	(0.0078)	(0.0879)	(0.0795)	(0.3185)
Activity:	0.8333***	0.9676***	0.2438***	0.5129***	0.8330***	1.3582***
Wetland	(0.0555)	(0.2184)	(0.0078)	(0.0879)	(0.0795)	(0.3185)
Activity:	-0.7721***	-0.8563***	-0.2918***	-0.6118***	-0.7720***	-1.0351***
Trees	(0.0555)	(0.2184)	(0.0078)	(0.0879)	(0.0795)	(0.3185)
Activity:	-0.0611	-0.1113	0.0480***	0.0989	-0.0611	-0.3231
Meadow[b]	(0.0555)	(0.2184)	(0.0078)	(0.0879)	(0.0795)	(0.3185)
Technical	-0.0661*	-0.8648***	-0.0632***	-0.3930***	-0.0660	-1.0566***
help: Yes	(0.0393)	(0.1544)	(0.0055)	(0.0622)	(0.0562)	(0.2252)
Technical	0.0661*	0.8648***	0.0632***	0.3930***	0.0660	1.0566***
help: No[b]	(0.0393)	(0.1544)	(0.0055)	(0.0622)	(0.0562)	(0.2252)
Recognition:	0.0194	-0.2228	0.0170***	-0.0046	0.0194	-0.2567
Yes	(0.0393)	(0.1544)	(0.0055)	(0.0622)	(0.0562)	(0.2252)
Recognition:	-0.0194	0.2228	-0.0170***	0.0046	-0.0194	0.2567
No[b]	(0.0393)	(0.1544)	(0.0055)	(0.0622)	(0.0562)	(0.2252)
Payment:	0.2629***		0.1862***		0.2628**	
$0	(0.0878)		(0.0124)		(0.1258)	
Payment:	0.2210**		0.0945***		0.2209*	
$50	(0.0878)		(0.0124)		(0.1258)	
Payment:	0.0908		0.0075		0.0908	
$100	(0.0878)		(0.0124)		(0.1258)	
Payment:	-0.1285		-0.0591***		-0.1285	
$150	(0.0878)		(0.0124)		(0.1258)	
Payment:	-0.1820**		-0.0964***		-0.1820	
$200	(0.0878)		(0.0124)		(0.1258)	
Payment:	-0.2641***		-0.1327***		-0.2641**	
$250[b]	(0.0878)		(0.0124)		(0.1258)	
Grand to	-0.0061	-0.1452	-0.0047	-0.1453**		
Thames	(0.0393)	(0.1544)	(0.0055)	(0.0622)		
Thames to	0.0061	0.1452	0.0047	0.1453**		
Grand[b]	(0.0393)	(0.1544)	(0.0055)	(0.0622)		
n	432	72	432	72	216	36
R^2	0.43	0.50	0.84	0.62	0.43	0.62

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

[a] Standard errors appear in brackets below the associated parameter estimates.

[b] Parameter estimate calculated as the negative of the associated parameters using the Delta method.

C5. Selected Results for Other Models

Certain results for the other models not presented in the main text are included in Appendix C5: unweighted by certainty with ln(payment); weighted by certainty with fixed payment; and unweighted by certainty with fixed payment. Each of these models was run six times and the iteration yielding the lowest log-likelihood chosen as the final model. We did not perform the Swait and Louviere test assessing the equality of model parameters, nor did we perform regressions of errors or tolerance intervals on transfer characteristics. Unlike Appendix C4, we do not include accompanying text.

Table C4: Random Parameter Models by Watershed

Variable	Unweighted With ln(Payment)		Weighted With Fixed Payment		Unweighted With Fixed Payment	
	Grand	Upper Thames	Grand	Upper Thames	Grand	Upper Thames
Mean						
ASC	1.1561***	0.9925**	0.9682**	1.4656***	1.1013***	1.3111***
	(0.4419)	(0.4154)	(0.4668)	(0.4718)	(0.3979)	(0.3782)
Acres	-0.6759***	-0.5543***	-0.7072***	-0.4534**	-0.6156***	-0.3554**
	(0.2051)	(0.2039)	(0.2320)	(0.2095)	(0.1788)	(0.1730)
Conversion Activity: Wetland	-1.2139***	-0.8556***	-1.2181***	-0.6805***	-1.0172***	-0.7098***
	(0.2251)	(0.1949)	(0.2639)	(0.1897)	(0.1970)	(0.1610)
Conversion Activity: Trees	1.5572***	1.6761***	1.4634***	1.4327***	1.2923***	1.4134***
	(0.1930)	(0.1932)	(0.2161)	(0.1954)	(0.1627)	(0.1586)
Conversion Activity:	-0.3433**	-0.8205***	-0.2453	-0.7521***	-0.2751**	-0.7036***
Meadow[a]	(0.1614)	(0.1675)	(0.1780)	(0.1766)	(0.1382)	(0.1455)
Technical help (Yes)	1.1181***	0.7516***	1.1560***	0.6722***	0.9814***	0.5924***
	(0.1852)	(0.1786)	(0.2154)	(0.1940)	(0.1643)	(0.1562)
Recognition (Yes)	-0.6847***	-0.6672***	-0.4926***	-0.5941***	-0.5025***	-0.5584***
	(0.1790)	(0.1609)	(0.1896)	(0.1553)	(0.1465)	(0.1289)
Annual payment	-5.2185***	-5.4795***	0.0092***	0.0075***	0.0083***	0.0070***
	(0.1989)	(0.2402)	(0.0012)	(0.0010)	(0.0009)	(0.0008)
Correlation (Lower-Triangular of the Cholesky Matrix)						
ASC × ASC	5.7724***	5.4252***	5.7609***	4.7935***	5.1523***	-4.6578***
	(0.7087)	(0.6496)	(0.7454)	(0.6277)	(0.5857)	(0.4980)
Acres × ASC	0.7916**	0.2854	1.0955***	0.6591*	1.0566***	-0.3663
	(0.3180)	(0.3085)	(0.3583)	(0.3378)	(0.2802)	(0.2840)
Wetland × ASC	0.6725**	-0.1317	0.8052**	-0.1185	0.6515**	0.1023
	(0.3407)	(0.2866)	(0.3749)	(0.3103)	(0.2959)	(0.2586)
Trees × ASC	-0.1224	0.5713**	-0.1804	0.6227**	-0.2016	-0.4711*
	(0.2797)	(0.2909)	(0.3071)	(0.3133)	(0.2372)	(0.2532)
Technical × ASC	-0.0984	0.0124	-0.3150	-0.1668	-0.3370	0.0828
	(0.2622)	(0.2648)	(0.3007)	(0.2845)	(0.2495)	(0.2391)
Recognition × ASC	0.0546	0.2485	-0.1172	0.0572	-0.0321	-0.0462
	(0.2633)	(0.2177)	(0.2846)	(0.2410)	(0.2222)	(0.2032)

Variable	Unweighted With ln(Payment)		Weighted With Fixed Payment		Unweighted With Fixed Payment	
	Grand	Upper Thames	Grand	Upper Thames	Grand	Upper Thames
Payment × ASC	-0.0520	-0.3906***				
	(0.1137)	(0.1033)				
Acres × Acres	1.8686***	1.6283***	-1.6241***	1.3325***	1.1495***	-1.4035***
	(0.3540)	(0.3060)	(0.3949)	(0.4503)	(0.3786)	(0.3595)
Wetland × Acres	0.1434	0.4954	-0.3218	0.6432	0.1828	-0.5350
	(0.3543)	(0.3468)	(0.4475)	(0.5650)	(0.3994)	(0.3483)
Trees × Acres	0.0955	-0.1000	-0.0468	-0.1014	0.1877	0.0491
	(0.2799)	(0.3040)	(0.3726)	(0.5005)	(0.3721)	(0.3052)
Technical × Acres	-0.1568	-0.6382**	0.1492	-0.7813**	-0.1587	0.7440**
	(0.3237)	(0.3239)	(0.4133)	(0.3972)	(0.4835)	(0.3131)
Recognition × Acres	-0.3206	0.0297	0.5076	-0.0950	-0.7275**	0.0122
	(0.3399)	(0.2466)	(0.3524)	(0.3118)	(0.3674)	(0.2397)
Payment × Acres	0.2454*	0.0136				
	(0.1299)	(0.1310)				
Wetland × Wetland	2.8884***	2.2425***	-2.6722***	1.8978***	-2.4080***	1.9136***
	(0.3287)	(0.2670)	(0.3230)	(0.3170)	(0.2397)	(0.2212)
Trees × Wetland	-1.7061***	-1.2286***	1.6531***	-1.1290***	1.4528***	-1.1143***
	(0.2575)	(0.2231)	(0.2624)	(0.2745)	(0.2068)	(0.2004)
Technical × Wetland	0.1858	0.4739**	-0.0695	0.4687*	-0.1312	0.4198**
	(0.2221)	(0.1990)	(0.2323)	(0.2557)	(0.1810)	(0.1862)
Recognition × Wetland	-0.2477	0.2018	0.1801	0.2548	0.1342	0.1857
	(0.2225)	(0.1760)	(0.2420)	(0.2203)	(0.2048)	(0.1713)
Payment × Wetland	0.1224	0.1472				
	(0.1476)	(0.1313)				
Trees × Trees	-1.4339***	-1.4194***	-1.2943***	-1.3485***	1.1418***	1.2680***
	(0.1825)	(0.1688)	(0.1916)	(0.1826)	(0.1622)	(0.1524)
Technical × Trees	0.7279***	0.3678*	0.4246	0.4292*	-0.4691*	-0.3452*
	(0.2430)	(0.2104)	(0.2755)	(0.2585)	(0.2739)	(0.1958)
Recognition × Trees	0.3757	0.2047	0.4354	0.2635	-0.3515	-0.1847
	(0.2418)	(0.1873)	(0.2660)	(0.2092)	(0.2677)	(0.1727)
Payment × Trees	0.1270	-0.6169***				
	(0.1499)	(0.1355)				

Variable	Unweighted With ln(Payment)		Weighted With Fixed Payment		Unweighted With Fixed Payment	
	Grand	Upper Thames	Grand	Upper Thames	Grand	Upper Thames
Technical × Technical	-1.0411***	0.6689*	-1.2895***	0.6673	-1.0851***	-0.5000
	(0.2732)	(0.3422)	(0.3347)	(0.4115)	(0.3093)	(0.3713)
Recognition × Technical	0.1417	0.0292	-0.1237	0.0939	-0.1227	-0.5064*
	(0.2986)	(0.3172)	(0.3810)	(0.4679)	(0.4127)	(0.3048)
Payment × Technical	0.8469***	-0.1722				
	(0.1582)	(0.1217)				
Recognition × Recognition	1.2416***	-0.1493	1.1899***	0.3517	-0.8122**	0.1254
	(0.3095)	(0.2881)	(0.3331)	(0.4760)	(0.3969)	(0.4886)
Payment × Recognition	-0.9667***	1.4339***				
	(0.1784)	(0.1662)				
Payment × Payment	0.0934	-0.0411				
	(0.1362)	(0.2271)				
Model Statistics						
Log-Likelihood	-1755.78	-1548.62	-1265.89	-1131.23	-1780.84	-1573.11
Observations	7263	6363	7263	6363	7263	6363
Pseudo R^2	0.34	0.33	0.35	0.34	0.33	0.32

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

[a] As activity variables are effects coded, meadow parameter derived as negative of other activity parameters via the Delta method

Table C5: Results of the Log-Likelihood Tests Comparing Models with Log-Normal and Fixed Payment

Watershed	Certainty Calibration	
	Weighted	Unweighted
Upper Thames	$X^2_{(7)} = 34.79$ with $p < 0.01$	$X^2_{(7)} = 48.99$ with $p < 0.01$
Grand	$X^2_{(7)} = 35.12$ with $p < 0.01$	$X^2_{(7)} = 50.12$ with $p < 0.01$

C5.1 Output from the Model with Log-Normal Payment and No Calibration for Certainty

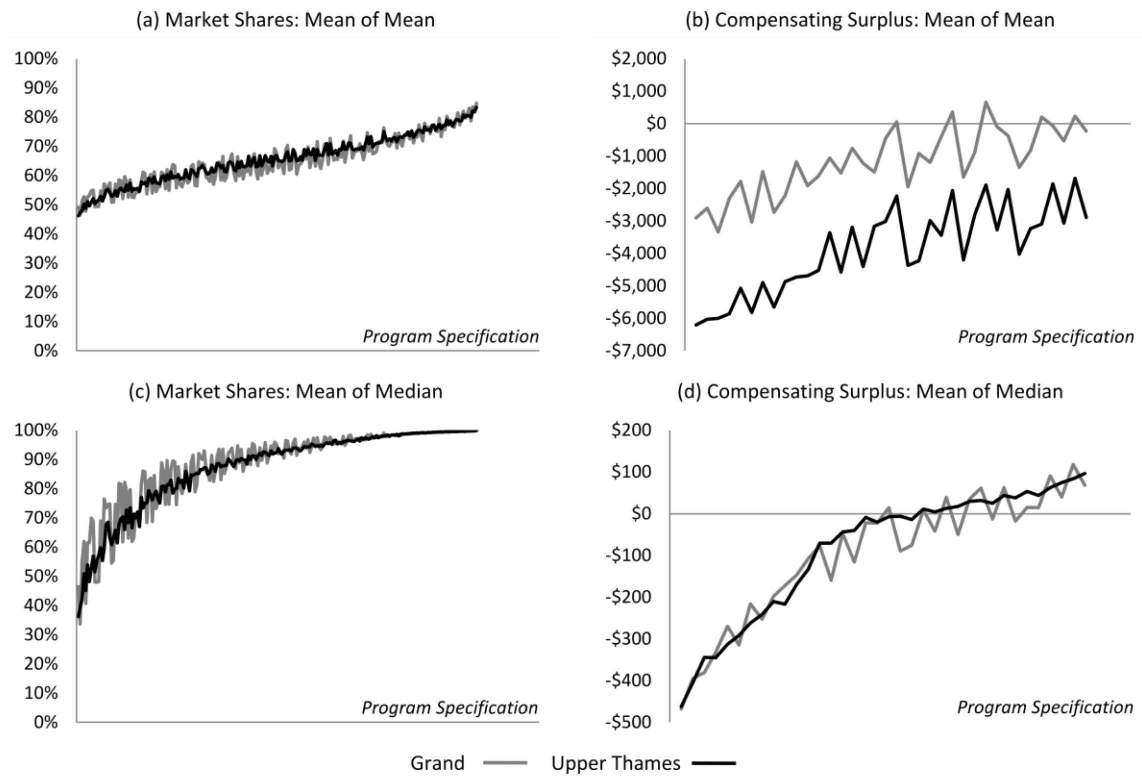

Figure C4: Market Share (a, c) and Compensating Surplus (b, d) Estimates
Note: for both panels the x-axis represents all possible program specifications (e.g., for panels (a) and (c) a point on this axis represents a program with 0.5 acres converted to wetlands with no technical help or recognition and a payment of $50, etc. and the points on this axis in panels (b) and (d) are similar though do not include a payment component.

Table C6: Summary of Reliability and Validity Tests

Transfer	Transfer Errors (%)				Tolerance Levels (%)				Complete Combinatorial
	Mean	Median	Low	High	Mean	Median	Low	High	
Mean of Mean									
Directional									
MS: Grand to Thames	3	2	0	9	12	12	5	22	
MS: Thames to Grand	3	2	0	9	12	12	5	20	N/A
CS: Grand to Thames	75	69	44	135	223	209	175	336	
CS: Thames to Grand	583	224	80	3856	1609	691	315	9811	
Non-Directional									
MS: Grand and Thames	3	2	0	9		N/A			9*, 0**, 0***
CS: Grand and Thames	132	106	57	416					17*, 7**, 1***
Mean of Median									
Directional									
MS: Grand to Thames	4	2	0	32	18	11	1	100	
MS: Thames to Grand	4	2	0	24	18	11	1	100	N/A
CS: Grand to Thames	143	35	1	1394	537	244	69	3288	
CS: Thames to Grand	65	30	1	310	313	184	68	1114	
Non-Directional									
MS: Grand and Thames	4	2	0	28		N/A			4*, 0**, 0***
CS: Grand and Thames	106	34	1	626					1*, 0**, 0***

*, **, and *** indicate the number of pairs of estimates that are different at the 90%, 95%, and 99% levels of significance, respectively

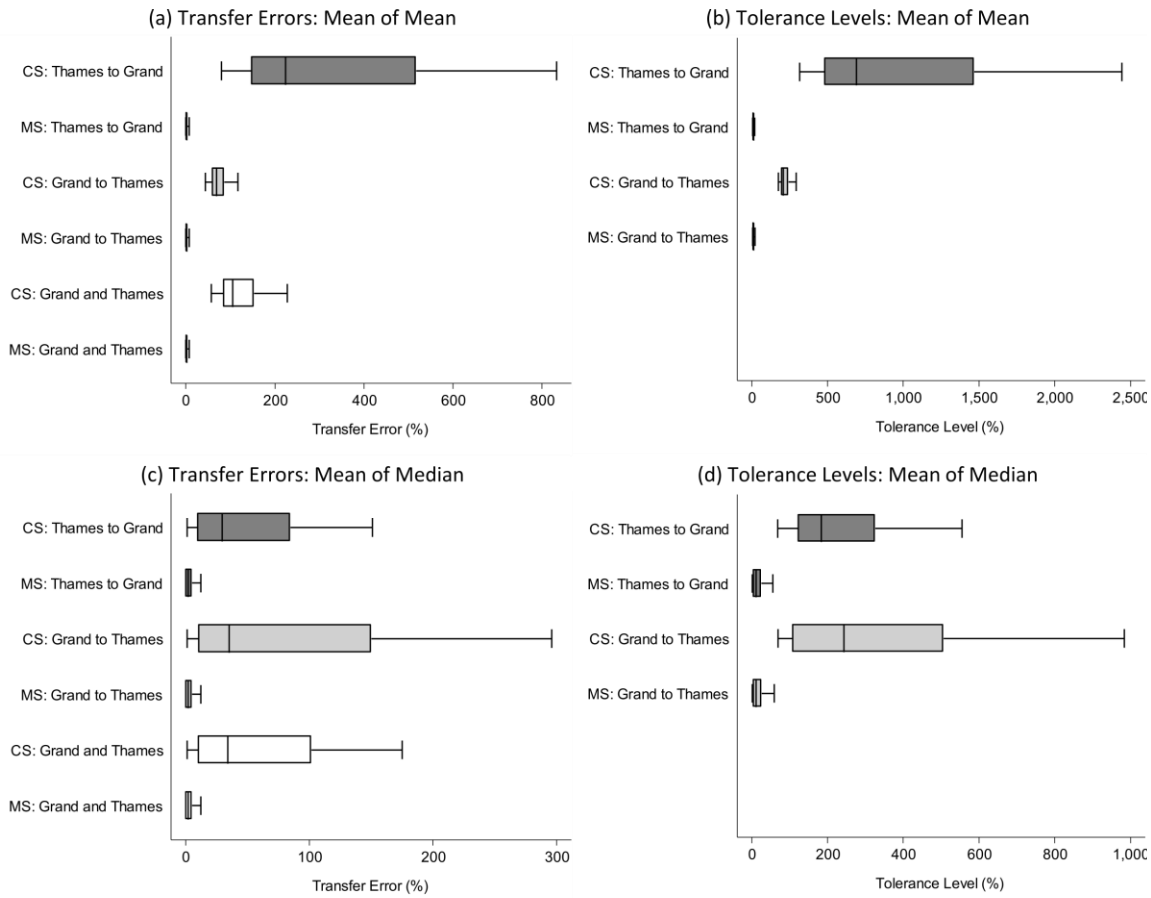

Figure C5: Boxplots of Transfer Errors and Tolerance Levels
Note: Outliers not plotted; non-directional errors are white and directional errors are differing shades of grey.

C5.2 Output from the Model with Fixed Payment and Calibration for Certainty

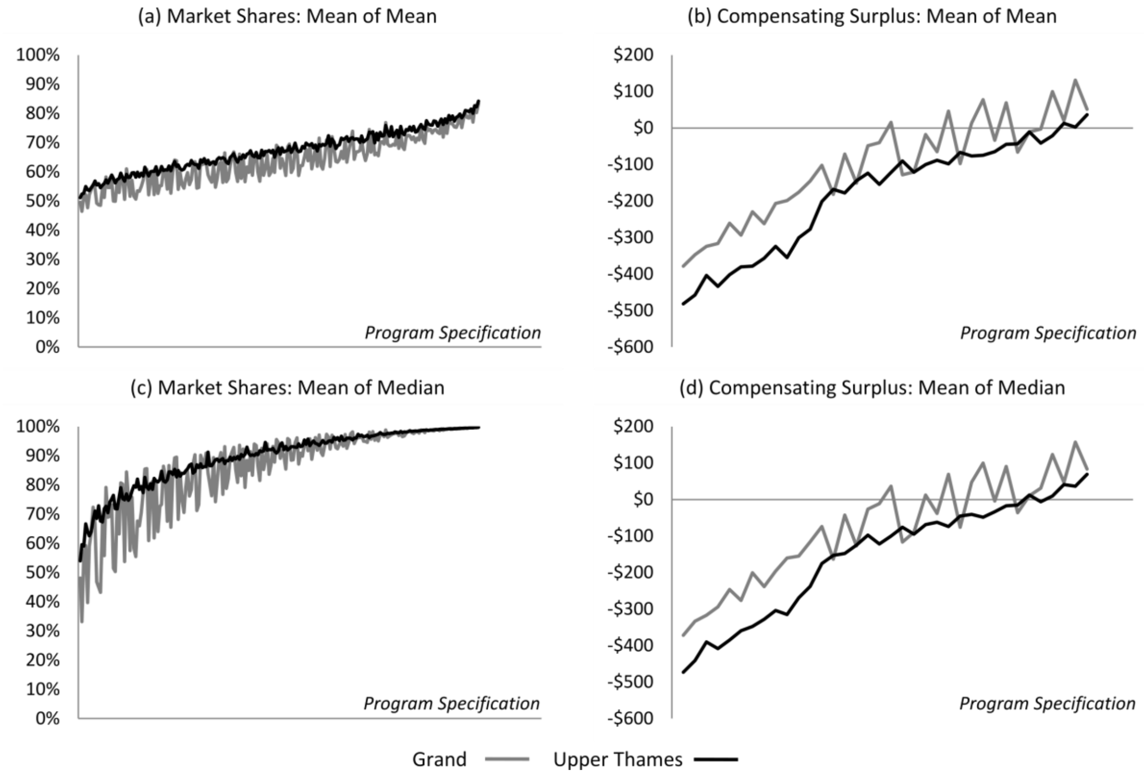

Figure C6: Market Share (a, c) and Compensating Surplus (b, d) Estimates
Note: for both panels the x-axis represents all possible program specifications (e.g., for panels (a) and (c) a point on this axis represents a program with 0.5 acres converted to wetlands with no technical help or recognition and a payment of $50, etc. and the points on this axis in panels (b) and (d) are similar though do not include a payment component.

Table C7: Summary of Reliability and Validity Tests

Transfer	Transfer Errors (%)				Tolerance Levels (%)				Complete Combinatorial
	Mean	Median	Low	High	Mean	Median	Low	High	
Mean of Mean									
Directional									
MS: Grand to Thames	5	4	0	14	16	15	8	26	N/A
MS: Thames to Grand	6	5	0	16	17	16	8	30	
CS: Grand to Thames	199	45	1	4618	583	181	56	11,000	
CS: Thames to Grand	168	61	1	1532	608	235	71	7665	
Non-Directional									
MS: Grand and Thames	6	5	0	15	N/A				58*, 18**, 0***
CS: Grand and Thames	465	47	1	12,779					7*, 0**, 0***
Mean of Median									
Directional									
MS: Grand to Thames	6	3	0	44	21	15	1	93	N/A
MS: Thames to Grand	7	3	0	79	24	15	1	166	
CS: Grand to Thames	134	50	2	1153	465	225	56	3106	
CS: Thames to Grand	144	68	1	964	509	221	71	3920	
Non-Directional									
MS: Grand and Thames	6	3	0	57	N/A				12*, 0**, 0***
CS: Grand and Thames	332	54	1	5744					6*, 0**, 0***

*, **, and *** indicate the number of pairs of estimates that are different at the 90%, 95%, and 99% levels of significance, respectively

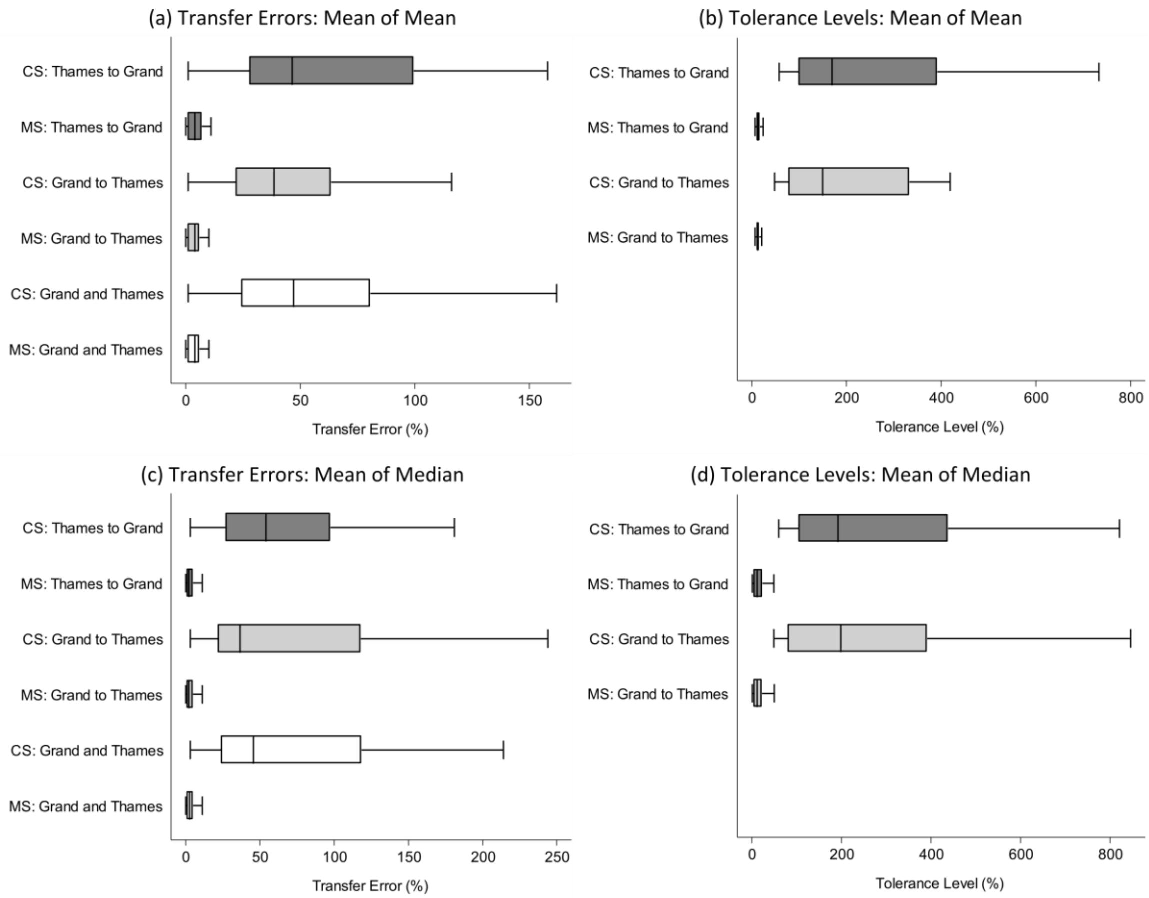

Figure C7: Boxplots of Transfer Errors and Tolerance Levels
Note: outliers not plotted; non-directional errors are white and directional errors are differing shades of grey.

C5.3 Output from the Model with Fixed Payment and No Calibration for Certainty

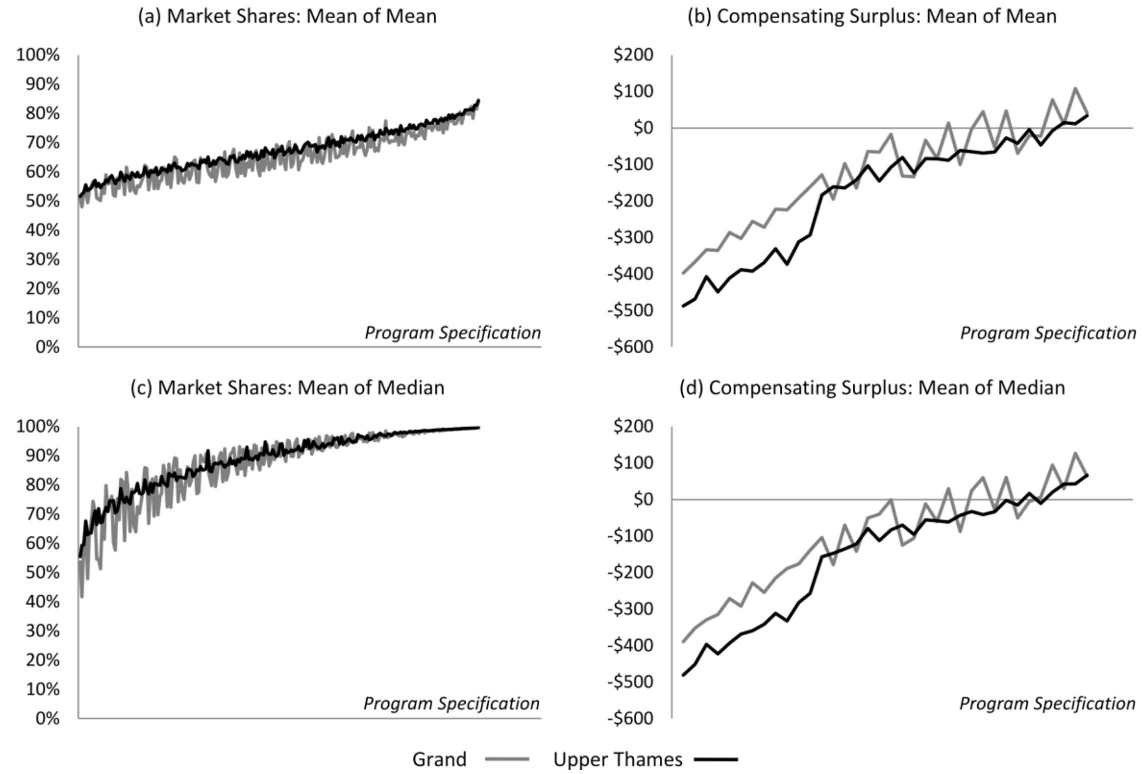

Figure C8: Market Share (a, c) and Compensating Surplus (b, d) Estimates
Note: for both panels the x-axis represents all possible program specifications (e.g., for panels (a) and (c) a point on this axis represents a program with 0.5 acres converted to wetlands with no technical help or recognition and a payment of $50, etc. and the points on this axis in panels (b) and (d) are similar though do not include a payment component.

Table C8: Summary of Reliability and Validity Tests

Transfer	Transfer Errors (%)				Tolerance Levels (%)				Complete Combinatorial
	Mean	Median	Low	High	Mean	Median	Low	High	
Mean of Mean									
Directional									
MS: Grand to Thames	4	4	0	10	13	13	7	21	N/A
MS: Thames to Grand	4	4	0	11	14	13	7	24	
CS: Grand to Thames	111	38	1	1111	413	150	48	3157	
CS: Thames to Grand	159	46	1	2464	543	170	58	8094	
Non-Directional									
MS: Grand and Thames	4	4	0	10	N/A				28*, 0**, 0***
CS: Grand and Thames	108	47	1	945					7*, 0**, 0***
Mean of Median									
Directional									
MS: Grand to Thames	4	2	0	30	16	12	1	73	N/A
MS: Thames to Grand	4	2	0	42	17	12	1	104	
CS: Grand to Thames	157	37	3	3012	559	199	49	9330	
CS: Thames to Grand	447	54	3	12,904	1341	193	60	34,000	
Non-Directional									
MS: Grand and Thames	4	2	0	35	N/A				6*, 0**, 0***
CS: Grand and Thames	165	45	3	1376					4*, 0**, 0***

*, **, and *** indicate the number of pairs of estimates that are different at the 90%, 95%, and 99% levels of significance, respectively

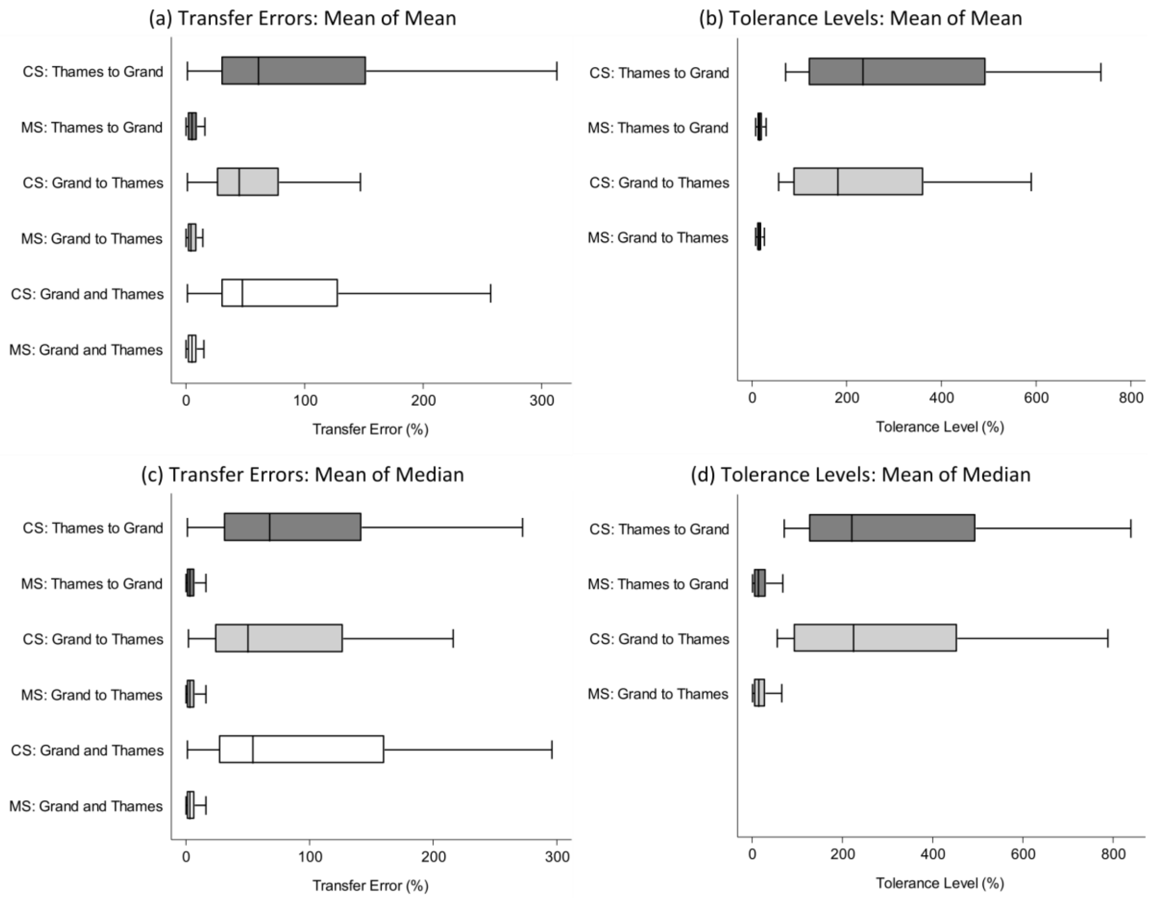

Figure C9: Boxplots of Transfer Errors and Tolerance Levels
Note: outliers not plotted; non-directional errors are white and directional errors are differing shades of grey.

References

Hole, A. R. (2007). Fitting mixed logit models by using maximum simulated likelihood. *The Stata Journal*, *7*(3), 388–401.

Appendix D.

Supplementary Material for Chapter 5

D1. Demographic Characteristics of Each Watershed

There is a near even split of genders of the population in or near each watershed, although the Ontario watersheds have slightly more females than males, while the Salmon has slightly more males than females (Table D1). On average, residents of the Humber are youngest, followed very closely by those in the Credit, and then more distantly by residents of the Little and Salmon watersheds. Overall, residents of the Humber appear most educated, followed by the Credit or Salmon, and then the Little. However, those holding a post-secondary diploma or bachelor's degree form the largest group in each watershed. In all but the Little, the second largest group is those with a high school diploma, followed by those with less than high school, and then those with a graduate degree (in the Little the second and third largest groups switch places). The proportion of those employed is similar across watersheds, though highest in the Credit, followed by the Little, Humber, and then Salmon, while the proportion of those not in the labour force forms the second largest group and is highest in the Salmon, followed by the Humber, Little, and Credit. The unemployment rate is highest in the Little, followed by the Humber, Credit, and then more distantly the Salmon. On average, residents of the two Ontario watersheds have the highest income — with the income of those in the Credit a little higher than the Humber — followed by the Salmon, and then the Little.

Table D1: Key Demographic Characteristics for the Little, Humber, Credit, and Salmon River Watersheds

Watershed Characteristics[a]	Little	Humber	Credit	Salmon
Gender (%)				
Female	50.0	51.4	51.0	49.6
Male	50.0	48.6	49.0	50.4
Age in years				
Weighted mean of dissemination area medians	44.2	38.3	38.5	49.3
Education (%)				
Less than high school	33.8	24.4	15.9	20.1
High school	29.7	27.9	26.6	32.3
Diploma or bachelor's degree	34.7	40.1	47.1	43.5
Graduate degree	1.7	7.6	10.4	4.0
Employment status (%)				
Employed	59.2	59.1	64.0	57.5
Unemployed	6.8	5.4	5.3	4.0
Not in labour force	34.0	35.6	30.7	38.5
Income (%)				
Less than $10,000	0.0	2.2	1.7	0.8
$10,000 to $29,999	21.6	12.8	7.9	15.9
$30,000 to $49,999	27.9	17.9	12.0	24.2
$50,000 to $79,999	25.8	22.5	23.2	27.1
$80,000 to $99,999	7.0	11.7	13.8	16.4
$100,000 or more	17.8	32.9	41.3	15.6

[a] Data are for dissemination areas that intersect with each watershed's boundaries. Gender and age data are from the 2011 Census of Population, while education, employment status, and income data are from the 2011 National Household Survey (Statistics Canada 2012; Statistics Canada 2013).

D2. The Choice Experiment Preamble and First Choice Set

Section 4: Your Preferences for Environmental Stewardship Programs in the Little River Watershed

Environmental conditions in the watershed can be maintained and/or improved through various government-funded environmental stewardship programs.

On the following pages, we will ask you to choose between different programs that would improve environmental conditions <u>10 years from now</u> in the watershed. Each question will ask you to choose 1 of 3 environmental stewardship programs: A, B, or C.

<u>Example</u>:

<u>Chose between three programs</u>

Environmental programs can increase the % of land that is protected to support wildlife in the region

Environmental programs can reduce the frequency of threats to water quality

Environmental programs may reduce farm/woodlot incomes by taking some land out of production

Environmental programs in this watershed will be paid for by an increase in your taxes for the next <u>10 years</u>

	Program A (similar to today)	Program B	Program C
Wildlife Habitat 	<u>5%</u> of land protected	<u>15%</u> of land protected	<u>25%</u> of land protected
Water Quality 	Quality <u>often</u> threatened	Quality <u>sometimes</u> threatened	Quality <u>rarely</u> threatened
Farm/Woodlot Income 	<u>0%</u> decrease in income	<u>20%</u> decrease in income	<u>10%</u> decrease in income
Additional Income Tax (for you for 10 years) 	$0/yr	$50/yr	$100/yr
I WOULD CHOOSE *(Please check only one)*	➡ Program A ☐	Program B ☒	Program C ☐

Please assess each of the following 6 Choice Sets and choose your preferred option.

Consider each set independently and imagine that you would have to actually dig into your household budget and pay the additional taxes.

CHOICE SET 1:

13. If Programs A, B, and C below were the only ones available in the watershed, which one would you choose?
Please check the box that corresponds with your answer.

	Program A (similar to today)	Program B	Program C
Wildlife Habitat 	5% of land protected	25% of land protected	5% of land protected
Water Quality 	Quality often threatened	Quality often threatened	Quality rarely threatened
Farm/Woodlot Income 	0% decrease in income	20% decrease in income	20% decrease in income
Additional Income Tax (for you for 10 years) 	$0/yr	$75/yr	$25/yr
I WOULD CHOOSE *(Please check only one)* ➡	Program A ☐	Program B ☐	Program C ☐

15. How certain are you about the program choice you made above?

☐	☐	☐	☐	☐
Certain	Somewhat Certain	Somewhat Uncertain	Uncertain	Don't Know

D3. The Random Parameters Logit Model

Choice modelling is rooted in McFadden's (1974) random utility model. Given a set of alternatives and assuming rational preferences, a respondent will select the alternative that yields the largest utility (U). Formally, individual *n* chooses alternative *j* instead of alternative *i* if and only if $U_{nj} > U_{ni} \; \forall \; j \neq i$. Utility is divisible into deterministic (V) and stochastic (ε) portions, which account for observable and unobservable characteristics impacting utility, respectively (Train 2009). The most basic model, the conditional logit, rests on a series of assumptions including homogenous preferences (although heterogeneity may be introduced by interacting variables with observable respondent characteristics). Random parameter logit (RPL) models relax these assumptions and account for preference heterogeneity by allowing model parameters to vary across individuals (Train 2009). Thus, the utility of consuming an alternative *i* varies across individuals, as in Equation D1.

$$U_{ni} = V_{ni} + \varepsilon_{ni} = \alpha_n + \beta_n x_{ni} + \varepsilon_{ni} \tag{D1}$$

Where α_n is a constant term and β_n is a parameter reflecting the marginal utility of characteristics of the good or service x_{ni}. Preference parameters are assumed to be randomly distributed in the population with continuous density $f(\beta_n|\theta)$. Using the RPL model it is possible to estimate population parameters for the moments that describe each preference parameter's distribution ($\theta = \{b, \eta_n\}$). Randomly distributed preference parameters are split into mean tastes (b) and individual-specific deviations from this mean (η_n) such that $\beta_n = b + \eta_n$ (Revelt and Train 1998). The model conforms to a probabilistic model of choice since we can only observe x_{ni} and not β_n. The probability of a sequence of choices is estimated as a weighted average of logits. In this case, the unconditional probability is the integral of the product of standard logits over each potential value of β_n weighted by the density function $f(\beta_n|\theta)$.

$$Pr_{ni} = \int \frac{e^{\mu \beta_n' x_{ni}}}{\sum_j e^{\mu \beta_n' x_{nj}}} f(\beta_n|\theta)\, d\beta_n \tag{D2}$$

This integral does not have a closed form, which requires the use of simulation to approximate the probability and involves taking several Halton draws of the preference parameters in a simulated maximum likelihood. In order to estimate the parameters characterizing each random parameter's distribution we must assume a distribution for the random preference parameters (Train 2009).

D4. Wildlife Habitat Level Comparisons for the 'Relative' and 'Absolute' Approaches

The levels compared for each approach are listed in Table D2.

Table D2: Values of the Habitat Attribute Compared for Each Reconciliation Approach by Watershed Pair

Approach	Little & Humber	Little & Credit	Little & Salmon	Humber & Credit	Humber & Salmon	Credit & Salmon
Relative	5 & 30, 15 & 40, 25 & 50	5 & 25, 15 & 35, 25 & 45	5 & 10, 15 & 20, 25 & 30	30 & 25, 40 & 35, 50 & 45	30 & 10, 40 & 20, 50 & 30	25 & 10, 35 & 20, 45 & 30
Absolute	5 & 5, 15 & 15, 25 & 25 30 & 30, 40 & 40, 50 & 50	5 & 5, 15 & 15, 25 & 25 25 & 25, 35 & 35, 45 & 45	5 & 5, 15 & 15, 25 & 25 10 & 10, 20 & 20, 30 & 30	30 & 30, 40 & 40, 50 & 50 25 & 25, 35 & 35, 45 & 45	30 & 30, 40 & 40, 50 & 50 10 & 10, 20 & 20, 30 & 30	25 & 25, 35 & 35, 45 & 45 10 & 10, 20 & 20, 30 & 30

D5. Response Rates

Response rates for each watershed are presented in Table A3.

Table D3: Response rates

	Little	Humber	Credit	Salmon
Returns (fully or partially completed)	386	318	345	460
Used in analysis	275	239	260	354
Returns/Delivered	50%	41%	44%	59%
Used/Delivered	35%	31%	33%	45%

D6. Variance-Covariance and Standard Deviation Parameters Estimated from the Lower Triangular of the Cholesky-Matrix

The variance-covariance matrices (Σ) were generated by taking the product of the lower-triangular of the Cholesky matrix (L) and its transpose ($\Sigma = LL'$). Standard deviation parameters were derived by squaring each element of the lower-triangular of the Cholesky matrix and then taking the square root of the of the sum of the resulting values by row. We used Hole's (2007) Stata 12.1 ‘mixclov’ command for this task.

Table D4: Variance-Covariance and Standard Deviation Parameters for the Little Watershed Models

Little	Variance-Covariance Matrix							Standard Deviation
	ASC	Habitat	Habitat^2	WQ: sometimes	WQ: rarely	Income	Income^2	
Linear Specification								
ASC	3.8830***							1.9705***
	(0.7655)							(0.1942)
Habitat	1.4606***	1.0449***						1.0222***
	(0.4488)	(0.3697)						(0.1809)
WQ:	2.3044***	0.6530*		2.7070***				1.6453***
sometimes	(0.5896)	(0.3753)		(0.7416)				(0.2254)
WQ: rarely	0.2314	-0.0525		0.3324	0.5060**			0.7113***
	(0.3197)	(0.1795)		(0.2658)	(0.2337)			(0.1643)
Income	-0.4097	-0.3440		-0.2738	-0.0086	0.4482*		0.6695***
	(0.3310)	(0.2261)		(0.2874)	(0.1515)	(0.2446)		(0.1827)
Quadratic Specification								
ASC	4.8025***							2.1915***
	(1.0318)							(0.2354)
Habitat	2.1031***	1.7390***						1.3187***
	(0.6409)	(0.5961)						(0.2260)
Habitat^2	-0.1659	-0.1703	1.2720**					1.1278***
	(0.5375)	(0.3739)	(0.6014)					(0.2666)
WQ:	2.9871***	1.1881**	0.1969	3.7562***				1.9381***
sometimes	(0.8151)	(0.5782)	(0.4264)	(1.1034)				(0.2847)
WQ: rarely	0.3733	-0.0167	0.1710	0.3588	0.6646*			0.8152***
	(0.4269)	(0.2751)	(0.3037)	(0.3484)	(0.3587)			(0.2200)
Income	-0.6804	-0.4941	0.1365	-0.3914	-0.1591	0.5388*		0.7340***
	(0.4226)	(0.3215)	(0.3165)	(0.4020)	(0.2292)	(0.3164)		(0.2156)
Income^2	-0.6699	0.0397	-0.1089	-0.7531	0.1030	-0.2624	0.5162	0.7185**
	(0.5327)	(0.3506)	(0.3870)	(0.4855)	(0.2609)	(0.2490)	(0.4178)	(0.2908)

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

Table D5: Variance-Covariance and Standard Deviation Parameters for the Humber Watershed Models

Humber	Variance-Covariance Matrix							Standard Deviation
	ASC	Habitat	Habitat^2	WQ: sometimes	WQ: rarely	Income	Income^2	
Linear Specification								
ASC	4.7490***							2.1792***
	(1.1340)							(0.2602)
Habitat	0.3725	0.9445***						0.9718***
	(0.4274)	(0.3623)						(0.1864)
WQ:	1.2580**	0.4685		2.4482***				1.5647***
sometimes	(0.5948)	(0.3352)		(0.7306)				(0.2335)
WQ: rarely	-0.0337	0.1511		0.7826**	0.3693			0.6077***
	(0.3775)	(0.1721)		(0.3132)	(0.2418)			(0.1990)
Income	-0.1304	-0.0853		-0.2592	-0.0611	0.0566		0.2380
	(0.3137)	(0.1683)		(0.2660)	(0.1117)	(0.1314)		(0.2761)
Quadratic Specification								
ASC	5.2951***							2.3011***
	(1.3183)							(0.2865)
Habitat	0.2419	1.1002***						1.0489***
	(0.4964)	(0.4154)						(0.1980)
Habitat^2	0.0975	-0.1847	0.1990					0.4461
	(0.4877)	(0.2694)	(0.2873)					(0.3221)
WQ:	1.4424**	0.6284	-0.2017	2.7017***				1.6437***
sometimes	(0.7174)	(0.3858)	(0.2862)	(0.8598)				(0.2615)
WQ: rarely	0.0868	0.2029	0.0333	0.8075**	0.4292			0.6551***
	(0.4429)	(0.1928)	(0.1373)	(0.3522)	(0.2677)			(0.2043)
Income	-0.2597	-0.0381	-0.0774	-0.3033	-0.1148	0.1408		0.3752
	(0.3790)	(0.1841)	(0.1332)	(0.3119)	(0.1468)	(0.1886)		(0.2513)
Income^2	-0.0568	0.4406	0.0167	-0.3492	-0.1014	-0.0267	0.4069	0.6379**
	(0.5793)	(0.2985)	(0.1957)	(0.3719)	(0.1850)	(0.1526)	(0.3667)	(0.2875)

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

Table D6: Variance-Covariance and Standard Deviation Parameters for the Credit Watershed Models

Credit	Variance-Covariance Matrix							Standard Deviation
	ASC	Habitat	Habitat2	WQ: sometimes	WQ: rarely	Income	$Income^2$	
Linear Specification								
ASC	5.1007***							2.2585***
	(1.1192)							(0.2478)
Habitat	1.2467***	0.6832**						0.8265***
	(0.4736)	(0.2956)						(0.1788)
WQ:	2.5944***	0.5231*		2.1830***				1.4775***
sometimes	(0.6549)	(0.3038)		(0.6428)				(0.2175)
WQ: rarely	0.7318*	0.4081**		0.8547***	0.8791***			0.9376***
	(0.4308)	(0.1862)		(0.3172)	(0.3292)			(0.1756)
Income	-0.0865	0.0078		0.1458	-0.0986	0.6425**		0.8015***
	(0.4047)	(0.1812)		(0.2646)	(0.1779)	(0.2683)		(0.1673)
Quadratic Specification								
ASC	6.1967***							2.4893***
	(1.4683)							(0.2949)
Habitat	1.7088***	1.1212**						1.0589***
	(0.6419)	(0.4493)						(0.2122)
$Habitat^2$	-0.3771	-0.3174	0.4678					0.6839***
	(0.5551)	(0.2716)	(0.3302)					(0.2414)
WQ:	3.4930***	0.9270**	-0.0056	3.0249***				1.7392***
sometimes	(0.9586)	(0.4495)	(0.3468)	(0.9448)				(0.2716)
WQ: rarely	1.1723**	0.5212*	-0.1796	0.9927**	1.3115***			1.1452***
	(0.5821)	(0.2772)	(0.2239)	(0.4135)	(0.4827)			(0.2108)
Income	-0.4269	0.0555	-0.3574*	0.1387	-0.1634	0.8932**		0.9451***
	(0.5123)	(0.2476)	(0.2086)	(0.3474)	(0.2462)	(0.3708)		(0.1962)
$Income^2$	-0.7749	-0.2837	0.1821	-0.7735*	-0.3305	-0.3112	0.3098	0.5566***
	(0.5907)	(0.3002)	(0.1896)	(0.4292)	(0.2690)	(0.2328)	(0.2321)	(0.2085)

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

Table D7: Variance-Covariance and Standard Deviation Parameters for the Salmon Watershed Models

Salmon	Variance-Covariance Matrix							Standard Deviation
	ASC	Habitat	Habitat^2	WQ: sometimes	WQ: rarely	Income	Income^2	
Linear Specification								
ASC	5.7388***							2.3956***
	(1.0825)							(0.2259)
Habitat	1.8868***	1.2049***						1.0977***
	(0.4890)	(0.3562)						(0.1623)
WQ: sometimes	1.9639***	0.3283		2.7944***				1.6716***
	(0.5630)	(0.3184)		(0.6385)				(0.1910)
WQ: rarely	0.4576	0.0794		0.6104***	0.5177**			0.7195***
	(0.3326)	(0.1658)		(0.2371)	(0.2064)			(0.1434)
Income	0.4019	-0.0975		-0.0480	0.0976	0.2029		0.4505***
	(0.3181)	(0.1607)		(0.2266)	(0.1087)	(0.1290)		(0.1432)
Quadratic Specification								
ASC	6.0755***							2.4648***
	(1.1648)							(0.2363)
Habitat	2.0316***	1.4867***						1.2193***
	(0.5377)	(0.4217)						(0.1729)
Habitat^2	0.0569	-0.2307	0.1291					0.3593*
	(0.4288)	(0.2444)	(0.1469)					(0.2044)
WQ: sometimes	2.0381***	0.4106	0.1202	2.8937***				1.7011***
	(0.5954)	(0.3313)	(0.1805)	(0.6837)				(0.2010)
WQ: rarely	0.5441	0.1363	0.1492	0.5940**	0.4622**			0.6798***
	(0.3551)	(0.1770)	(0.1271)	(0.2519)	(0.2082)			(0.1531)
Income	0.4197	-0.0332	0.0495	0.0248	0.0214	0.1146		0.3386*
	(0.3276)	(0.1649)	(0.0811)	(0.2244)	(0.1027)	(0.1337)		(0.1974)
Income^2	-0.0745	-0.1630	-0.0197	-0.4208	-0.2428	0.0340	0.2271	0.4765**
	(0.4496)	(0.2610)	(0.0968)	(0.2871)	(0.1497)	(0.1229)	(0.2209)	(0.2318)

*, **, and *** indicate that the parameter estimate differs from zero at the 90%, 95%, and 99% levels of significance, respectively

D7. Calculating Transfer Errors from the Quadratic Model

Since the wildlife habitat and producer income attributes were modeled as quadratic relationships the corresponding marginal WTP derived from these models is not constant across levels. The equations relating marginal WTP to the levels of each attribute are presented in Table D8 alongside the levels at which marginal WTP is zero (the asymptote resulting for the transfer errors).

Table D8: Marginal WTP for Changes in Extent of Wildlife Habitat and Deceases in Producer Income Derived from the Quadratic Model

Watershed	WTP Equation	Level at which WTP is $0
Extent of Wildlife Habitat		
Little	$-69.886(Habitat\ Level) + 11.397$	16.5%
Humber	$-22.353(Habitat\ Level) + 11.785$	52.7%
Credit	$-27.874(Habitat\ Level) + 11.813$	42.4%
Salmon	$-91.914(Habitat\ Level) + 21.103$	23.0%
Decline in Producer Income		
Little	$-35.7(Income\ Level) + 2.1381$	6.0%
Humber	$-77.159(Income\ Level) + 4.8285$	6.3%
Credit	$-65.137(Income\ Level) + 3.1815$	4.9%
Salmon	$-61.1(Income\ Level) + 1.4562$	2.4%

Since marginal WTP for wildlife habitat and producer income varies by level, transfer errors do as well. The equations for calculating directional errors are presented in Table D9.

Table D9: Equations for Calculating Transfer Errors for the Quadratic Wildlife Habitat and Producer Income

Transfer and Policy Site	Habitat Error	Income Error
Little & Humber		
Little	$\frac{-69.886H_L + 22.353H_H - 0.388}{-69.886H_L + 11.397}$	$\frac{-35.7I_L + 77.159I_H - 2.6904}{-35.7I_L + 2.1381}$
Humber	$\frac{-22.353H_H + 69.886H_L + 0.388}{-22.353H_H + 11.785}$	$\frac{-77.159I_H + 35.7I_L + 2.6904}{-77.159I_H + 4.8285}$
Little & Credit		
Little	$\frac{-69.886H_L + 27.874H_C - 0.416}{-69.886H_L + 11.397}$	$\frac{-35.7I_L + 65.137I_C - 1.0434}{-35.7I_L + 2.1381}$
Credit	$\frac{-27.874H_C + 69.886H_L + 0.416}{-27.874H_C + 11.813}$	$\frac{-65.137I_C + 35.7I_L + 1.0434}{-65.137I_C + 3.1815}$
Little & Salmon		
Little	$\frac{-69.886H_L + 91.914H_S - 9.706}{-69.886H_L + 11.397}$	$\frac{-35.7I_L + 61.1I_S - 0.6819}{-35.7I_L + 2.1381}$
Salmon	$\frac{-91.914H_S + 69.886H_L + 9.706}{-91.914H_S + 21.103}$	$\frac{-61.1I_S + 35.7I_L + 0.6819}{-61.1I_S + 1.4562}$
Humber & Credit		
Humber	$\frac{-22.353H_H + 27.874H_C - 0.028}{-22.353H_H + 11.785}$	$\frac{-77.159I_H + 65.137I_C + 1.647}{-77.159I_H + 4.8285}$
Credit	$\frac{-27.874H_C + 22.353H_H + 0.028}{-27.874H_C + 11.813}$	$\frac{-65.137I_C + 77.159I_H - 1.647}{-65.137I_C + 3.1815}$
Humber & Salmon		
Humber	$\frac{-22.353H_H + 91.914H_S - 9.318}{-22.353H_H + 11.785}$	$\frac{-77.159I_H + 61.1I_S + 3.3723}{-77.159I_H + 4.8285}$
Salmon	$\frac{-91.914H_S + 22.353H_H + 9.318}{-91.914H_S + 21.103}$	$\frac{-61.1I_S + 77.159I_H - 3.3723}{-61.1I_S + 1.4562}$
Credit & Salmon		
Credit	$\frac{-27.874H_C + 91.914H_S - 9.706}{-27.874H_C + 11.813}$	$\frac{-65.137I_C + 61.1I_S + 1.7253}{-65.137I_C + 3.1815}$
Salmon	$\frac{-91.914H_S + 27.874H_C + 9.706}{-91.914H_S + 21.103}$	$\frac{-61.1I_S + 65.137I_C - 1.7253}{-61.1I_S + 1.4562}$

Since WTP is not constant, there is an asymptote that occurs for errors when WTP at the policy site is \$0. We illustrate the effect of the asymptote on errors for transfers of wildlife habitat marginal WTP between the Little and Humber watersheds when the Little is treated as the policy site (Table D10 and Figure D1). For the sake of illustration, we assume the same habitat level at each site (which mimics the ‘absolute’ transfer approach).

Table D10: Equations for Calculating Transfer Errors for the Quadratic Wildlife Habitat and Producer Income

Habitat Level	Marginal WTP		Transfer Error
	Little	Humber	
5%	$7.95	$10.67	34%
6%	$7.26	$10.44	44%
7%	$6.57	$10.22	55%
8%	$5.89	$10.00	70%
9%	$5.20	$9.77	88%
10%	$4.51	$9.55	112%
11%	$3.82	$9.33	144%
12%	$3.13	$9.10	191%
13%	$2.44	$8.88	264%
14%	$1.75	$8.66	394%
15%	$1.06	$8.43	692%
16%	$0.38	$8.21	2088%
17%	-$0.31	$7.98	2646%
18%	-$1.00	$7.76	874%
19%	-$1.69	$7.54	546%
20%	-$2.38	$7.31	407%
21%	-$3.07	$7.09	331%
22%	-$3.76	$6.87	283%
23%	-$4.45	$6.64	249%
24%	-$5.14	$6.42	225%
25%	-$5.82	$6.20	206%

As can be seen in Figure D1, the asymptote occurs when the extent of wildlife habitat is around 16%. Errors near this level increase rapidly and are much higher than errors further from this level.

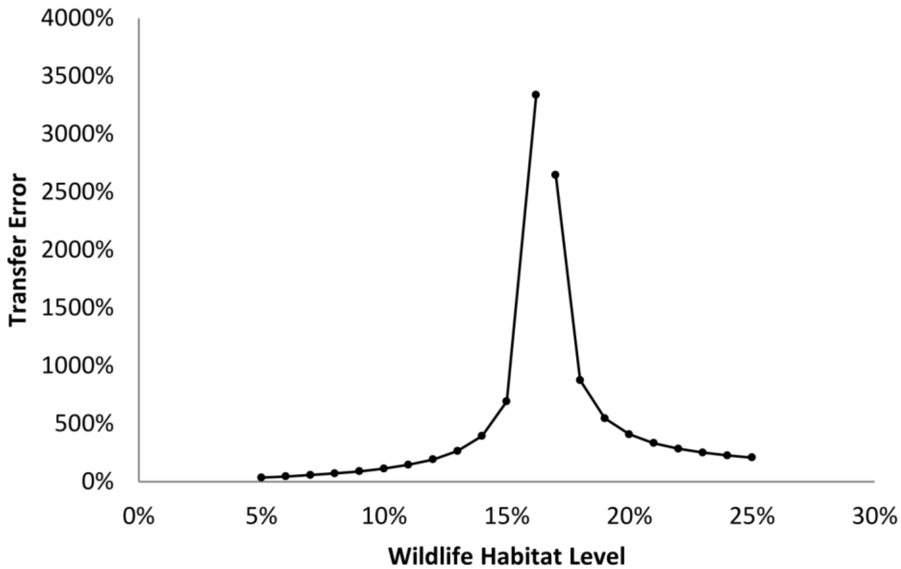

Figure D1: **Illustration of Errors for Transfers from the Humber to the Little Watersheds**

D8. Direct Comparisons of Transfer Error or Tolerance Level by Approach for Each Compensating Surplus Estimate

Table D11: **Reconciliation Approach Generating the Lowest Errors or Tolerance Level for Transfers of Compensating Surplus**[a]

Transfer and Policy Site	Transfer Errors			Tolerance Levels		
	'Absolute'	'Relative'	Equal[b]	'Absolute'	'Relative'	Equal[b]
Little & Humber						
Little	0	18	9	0	18	0
Humber	0	18	9	0	18	0
Little & Credit						
Little	0	18	9	0	18	0
Credit	0	18	9	0	18	0
Little & Salmon						
Little	0	18	9	0	18	0
Salmon	0	18	9	0	18	0
Humber & Credit						
Humber	0	18	9	0	18	0
Credit	0	18	9	0	18	0
Humber & Salmon						
Humber	0	18	9	0	18	0
Salmon	0	18	9	0	18	0
Credit & Salmon						
Credit	8	10	9	8	10	0
Salmon	0	17	10	0	18	1
Total	8	207	109	8	208	1

[a] Each cell represents the number of times the approach yields the lowest transfer error or tolerance level

[b] When habitat is at the status quo level the approaches yield identical errors and tolerance levels by default (108 cases)

Table D12: Model Generating the Lowest Errors or Tolerance Level for Transfers of Compensating Surplus[a]

Transfer and Policy Site	Transfer Errors						Tolerance Levels					
	'Relative' vs Linear			'Absolute' vs Linear			'Relative' vs Linear			'Absolute' vs Linear		
	'Relative'	Linear	Equal	'Absolute'	Linear	Equal	'Relative'	Linear	Equal	'Absolute'	Linear	Equal
Little & Humber												
Little	6	21	0	0	27	0	4	22	1	0	27	0
Humber	6	21	0	0	27	0	4	21	2	0	27	0
Little & Credit												
Little	12	15	0	0	27	0	11	14	2	0	27	0
Credit	12	15	0	0	27	0	10	14	3	0	27	0
Little & Salmon												
Little	9	18	0	0	27	0	12	14	1	0	27	0
Salmon	9	18	0	0	27	0	10	15	2	0	27	0
Humber & Credit												
Humber	0	27	0	0	27	0	0	27	0	0	27	0
Credit	0	27	0	0	27	0	0	27	0	0	27	0
Humber & Salmon												
Humber	3	24	0	0	27	0	2	23	2	0	27	0
Salmon	3	24	0	0	27	0	3	23	1	0	27	0
Credit & Salmon												
Credit	9	18	0	11	16	0	6	18	3	3	23	1
Salmon	9	18	0	4	23	0	8	16	3	7	16	4
Total	78	246	0	15	309	0	70	234	20	10	309	5

[a] Each cell represents the number of times the model or approach yields the lowest transfer error or tolerance level

D9. Examining Transfer Errors and Testing the Similarity of Marginal Estimates for the ASC and Water Quality

Overall, the ASC yields lower average errors and tolerance levels than the water quality attribute for both model specifications (Table D13). The errors and tolerance levels for changes in water quality from often to sometimes are larger than those for changes from often to rarely for all transfers involving the Little. For the remaining transfers the opposite holds for all tolerance levels and, in the case of the linear model, for errors in the case of transfers from the Humber to the Credit or Salmon. For the quadratic model, the errors are occasionally equal for the two changes in water quality although errors for often to sometimes are smaller for transfers from the Salmon to the Humber and errors for often to rarely are smaller for transfers from the Credit to the Salmon. Errors and tolerance levels for the ASC and changes in water quality are generally lower than the marginal values observed for the habitat and income attributes. The linear and quadratic specification yield similar errors, though the errors and tolerance levels are lower or equal for the linear model except for transfers of often to sometimes between the Little and Credit as well as transfers of often to rarely to the Salmon to the Credit. The tolerance levels are also smaller, except in the case of often to sometimes for transfers from the Little to the Credit. The complete combinatorial tests reveal that all of the pairs of estimates differ significantly at least at the 95% level of significance for transfers involving the Little. A handful of other pairs of estimates resulting from the quadratic specification differ significantly at the 90% level of significance for transfers between the Humber and Credit (water quality both) and Humber and Salmon (water quality often to rarely). Overall the share of estimate pairs deemed significantly different at the 95% are the same across attributes/levels, regardless of model specification.

Table D13: Errors, Tolerance Levels, and Complete Combinatorial p-values for Transfers of Non-Habitat Marginal WTP Estimates by Model[a]

Watersheds	Linear Specification			Quadratic Specification		
	ASC	WQ: Often to Sometimes	WQ: Often to Rarely	ASC	WQ: Often to Sometimes	WQ: Often to Rarely
Little & Humber						
Little	77 [136]	139 [198]	158 [214]	105 [173]	157 [222]	195 [260]
Humber	44 [77]	58 [83]	61 [83]	51 [85]	61 [87]	66 [88]
CC p-value	0.02**	0.00***	0.00***	0.01***	0.00***	0.00***
Little & Credit						
Little	74 [132]	103 [159]	123 [176]	80 [141]	96 [153]	125 [181]
Credit	43 [76]	51 [78]	55 [79]	45 [78]	49 [79]	56 [81]
CC p-value	0.01**	0.00***	0.00***	0.01**	0.00***	0.00***
Little & Salmon						
Little	78 [136]	107 [158]	136 [185]	88 [150]	107 [159]	137 [189]
Salmon	44 [77]	52 [76]	58 [79]	47 [80]	52 [77]	58 [80]
CC p-value	0.01**	0.00***	0.00***	0.01***	0.00***	0.00***
Humber & Credit						
Humber	2 [37]	15 [44]	13 [38]	12 [46]	24 [53]	24 [49]
Credit	2 [38]	18 [51]	16 [44]	13 [52]	31 [69]	31 [64]
CC p-value	0.47	0.19	0.18	0.28	0.09*	0.05*
Humber & Salmon						
Humber	1 [37]	13 [40]	9 [33]	8 [44]	19 [47]	20 [44]
Salmon	1 [36]	15 [46]	9 [36]	9 [48]	24 [58]	24 [54]
CC p-value	0.49	0.20	0.28	0.35	0.12	0.08*
Credit & Salmon						
Credit	2 [38]	2 [32]	6 [31]	4 [40]	6 [38]	5 [33]
Salmon	2 [37]	2 [31]	5 [30]	4 [38]	5 [36]	5 [32]
CC p-value	0.45	0.45	0.35	0.42	0.39	0.37
Overall						
Error[b]	31 (23)	48 (35)	54 (36)	39 (29)	53 (40)	62 (44)
Tolerance[b]	71 (57)	83 (64)	86 (62)	81 (65)	90 (73)	96 (72)

Watersheds	Linear Specification			Quadratic Specification		
	ASC	WQ: Often to Sometimes	WQ: Often to Rarely	ASC	WQ: Often to Sometimes	WQ: Often to Rarely
CC Different Pairs[c]	50%	50%	50%	50%	50%	50%

[a] Errors [tolerance levels in square brackets]

[b] Mean (median in round brackets)

[c] Percentage of CC tests deeming a pair of estimates different at the 95% level of significance

*, **, and *** indicate that the values differ from each other at the 90%, 95%, and 99% levels of significance, respectively

Transfer errors and tolerance levels are generally larger if a transfer involves the Little watershed. For the ASC, errors are lowest for transfers between the Humber and Salmon, followed by transfers between the Credit and Humber or Salmon, and the transfers involving the Little. Tolerance levels for the ASC are similar for transfers among the Humber, Credit, or Salmon and these levels are much smaller than those involving the Little watershed. For the quadratic specification, the order differs somewhat with transfers between the Credit and Salmon yielding the smallest errors, followed by transfers between the Humber and Salmon, Humber and Credit, Little and Credit, Little and Salmon, and Little and Humber. Tolerance levels for the quadratic ASC are lowest for the transfers between the Credit and Salmon, followed by transfers between the Humber and Credit or Salmon, and then Little and Credit, Little and Salmon, and Little and Humber. For the water quality attributes, transfer errors are lowest for transfers between the Credit and Salmon, followed by transfers between the Humber and Salmon or Credit, and then transfers between the Little and Credit, Little and Salmon, and Little and Humber (order same for linear and quadratic). Tolerance levels for the water quality attribute are lowest for transfers between the Credit and Salmon, followed by transfers between the Humber and Salmon, Humber and Credit, Little and Credit, Little and Salmon, and then the Little and Humber. Transfer direction appears to be more of a factor for transfers involving the Little watershed. Those transfers where the Little is the policy site yield much larger errors and tolerance levels. Direction does not impact errors and tolerance levels to the same extent for the other transfers, though transfers from the Humber to the Credit or Salmon as well as the Salmon to Credit yield errors and tolerance levels that are at least as large as in the other direction.

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Appendix E.

Landowner Choice Experiment Questionnaires

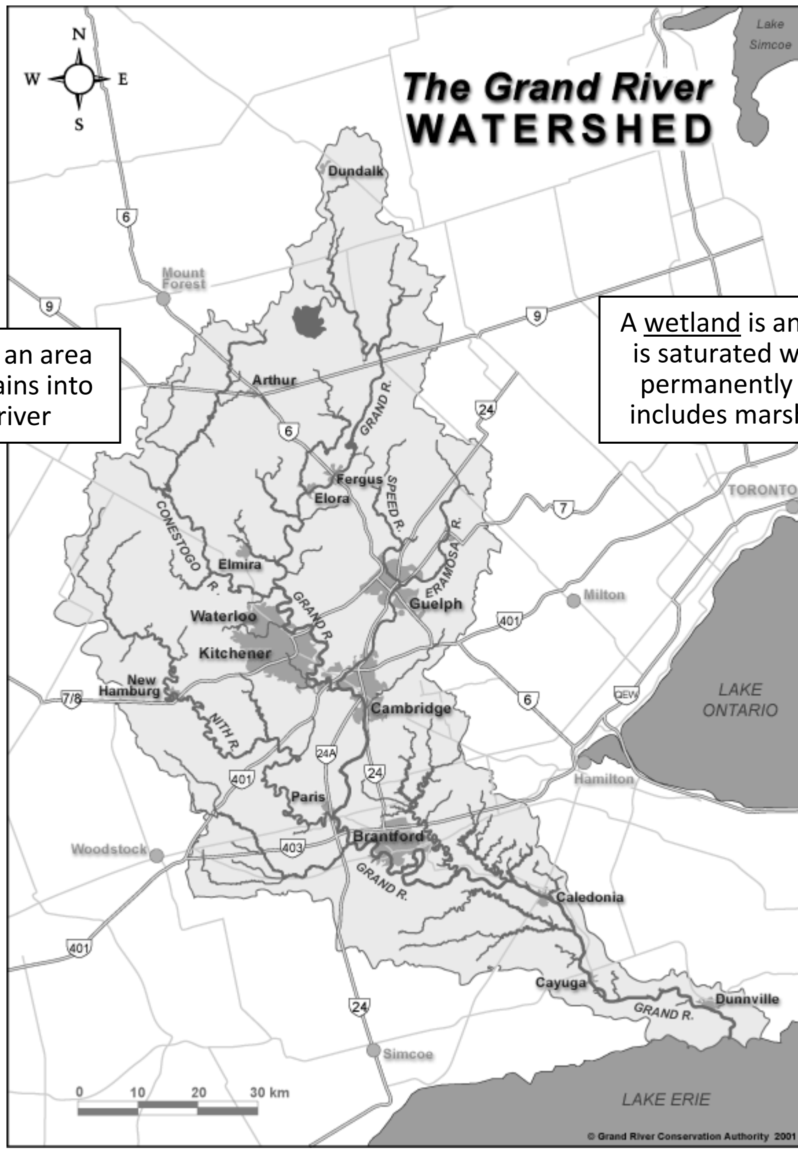
The questionnaires presented in this appendix are those used in the Grand River watershed. Those questionnaires used in the Upper Thames River watershed are identical in all respects except the map used on the cover page and the use of a different watershed name.

Farmer and Woodlot Owner Focussed Choice Experiment

Survey of Farmer Views on Wetland Enhancement and Restoration in & near the Grand River Watershed

A watershed is an area of land that drains into a common river

A wetland is an area of land that is saturated with water, either permanently or seasonally. It includes marshes and swamps.



When you have completed this survey, please place it in the postage-paid envelope provided in your survey package and drop it off in the mail. Thank you!

Section 1: Your Land

1. Which county or municipality do you live in? *Please check **one** box only.*

☐ Dufferin County ☐ Regional Municipality of Waterloo
☐ Wellington County ☐ Oxford County
☐ Haldimand County ☐ Brant County
☐ Perth County ☐ Other (Please specify): ______________________

2. What is the total area of land that you own inside and outside the Grand River watershed (if needed, consult the map on the back of the cover letter)?
Please indicate the number of acres in the spaces provided.

Inside: ________ Acres
Outside: ________ Acres

3. When did you first obtain land in the region? *Please check **one** box only.*

☐ Before 1970 ☐ 1981-1990 ☐ 2001-2006 ☐ Not Applicable
☐ 1970-1980 ☐ 1991-2000 ☐ 2007-2013

4. What is the primary use of the land you own? *Please check **one** box only.*

☐ Agriculture ☐ Residence
☐ Forestry ☐ Other: _________________________________

5. If you generated income from your land over the past 5 years, is it from any of the following? *Please check **all** boxes that apply.*

☐ Farming ☐ Leasing land for recreation ☐ Not applicable
☐ Forestry ☐ Leasing land for farming or forestry ☐ Other: _____________
☐ Leasing land for hunting ☐ Development/sale of your land _____________

6. What will likely happen to your land after you retire? *Please check **one** box only.*

☐ Sell ☐ Give to land trust ☐ Have not started planning for retirement
☐ Give to family ☐ Don't know ☐ Other: _____________________________

7. People own land for many different reasons. How important are each of the following reasons to you? *For each reason, please check the box that corresponds with your answer.*

	Very important	Important	Neither important or unimportant	Of little importance	Un-important	Don't know
To make a living (farm, forest, or other income)	☐	☐	☐	☐	☐	☐
To complement my income	☐	☐	☐	☐	☐	☐
As an investment for future gain	☐	☐	☐	☐	☐	☐
As a location for my permanent residence	☐	☐	☐	☐	☐	☐
For recreation (hunting, fishing, walking, etc.)	☐	☐	☐	☐	☐	☐
To maintain a family legacy	☐	☐	☐	☐	☐	☐
For the sake of our future generations	☐	☐	☐	☐	☐	☐
To preserve ecosystems	☐	☐	☐	☐	☐	☐

8. Which of the following features do you have on your land?
Please check ***all*** *boxes that apply.*

☐ Crop ☐ Pasture ☐ Meadows
☐ Orchard ☐ Forests ☐ Other: ________________________

9a. Do you have wetlands on your land?

☐ Yes ➨ *If yes, please continue with question* ***9b***
☐ No ➨ *If no, please skip to question* ***10***

9b. Did you create, or have you enhanced, any of these wetlands? *Check* ***all*** *boxes that apply.*

☐ Created them ☐ Enhanced them ☐ No

9c. If you created or enhanced any wetlands on your land, please explain what you did and how it was funded. *If you answered 'No' to question* ***9b*** *please skip to question* ***10****.*

____

____

____

Section 2: Your Land Management

10. How many acres of your land are currently left untilled or dedicated to other land cover types, and how have these areas changed since 2006?

Please indicate your answers using the spaces provided below. For any specific land cover type that does not apply to your situation, please leave the associated space blank.

Land cover type	# of acres now	Change since 2006: Increase (acres)	Change since 2006: Decrease (acres)
Land left untilled	________	________	________
Fence line	________	________	________
Wind break	________	________	________
Trees	________	________	________
Shrub land meadow	________	________	________
Ditch	________	________	________
Wet area / Wetland	________	________	________
Other conservation measure: ________________________ ________________________	________	________	________

11. Have you ever received financial incentives or cost-share payments from any of the following programs for implementing conservation measures on your land?

*Please check **all** boxes that apply.*

- ☐ Stewardship Program offered by the local Conservation Authority
- ☐ Environmental Farm Plan
- ☐ I have not received financial assistance from any program
- ☐ Ducks Unlimited Wetland Retention or Restoration Programs
- ☐ Other: ________________________________ ________________________________

12. To what extent do you agree or disagree with each of the following statements about your landowner rights?

For each statement, please check the box that corresponds with your answer.

<u>As a landowner, I have the **right** to…</u>	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
…restrict others' access to my land	☐	☐	☐	☐	☐	☐
…transfer ownership of my land to others without restriction	☐	☐	☐	☐	☐	☐
…do whatever I want with my land without regard for others	☐	☐	☐	☐	☐	☐
…do anything with my land as long as my actions do not infringe upon neighbours' rights	☐	☐	☐	☐	☐	☐
…do anything with my land as long as my actions do not conflict with the interests and values of the local community	☐	☐	☐	☐	☐	☐

13. To what extent do you agree or disagree with each of the following statements about your landowner responsibilities?

For each statement, please check the box that corresponds with your answer.

<u>As a landowner, I have the **responsibility** to…</u>	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
… be a good steward of my land and to maintain it in a good condition for future generations	☐	☐	☐	☐	☐	☐
… leave the land in a better condition than when I acquired it	☐	☐	☐	☐	☐	☐
… take into account the values and interests of society at large when making decisions about my land	☐	☐	☐	☐	☐	☐

Section 3: Wetland Management

Information: Wetland Benefits

Wetlands in your area provide a number of benefits to the community, including:

- ***Water quality:*** Wetlands help purify water.
- ***Flood, drought, and erosion control:*** Wetlands help control flooding and erosion, as well as reduce the impacts of drought.
- ***Wildlife habitat:*** Wetlands provide habitat for native and/or endangered plant and wildlife species (both on land and in water).
- ***Carbon storage:*** Wetlands store carbon helping to slow climate change.
- ***Recreation and education:*** Wetlands provide recreational and educational

14. How important are the following wetland benefits in your area to you?
*Please check **one** box per item.*

	Very important	Somewhat important	Not important	No opinion
Water quality	☐	☐	☐	☐
Flood, drought, and erosion control	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Carbon storage	☐	☐	☐	☐
Recreation and education	☐	☐	☐	☐

15. How would you describe the current state of wetlands in your area?
*Please check **one** box per item.*

	Excellent	Good	Fair	Marginal	Don't know
Quantity (amount) of wetlands	☐	☐	☐	☐	☐
Quality (health) of wetlands	☐	☐	☐	☐	☐
Accessibility to view wetlands	☐	☐	☐	☐	☐

Information: Decline in Wetland Area

- The area of wetlands in and around the Grand River watershed has declined significantly over the past century, largely due to human activities such as expansion of urban areas, agriculture, and industrial developments.
- While the rate of wetland loss has recently slowed, the area and/or quality of wetlands in your region still declines each year, resulting in further loss of wetland benefits.
- Landowners can help reverse the declining trend by enhancing existing wetlands and restoring previously drained ones on the land they manage.

16. In your opinion, what would motivate landowners in your region to participate in wetland enhancement and restoration activities on their land?
For each incentive, please check the box that corresponds with your answer.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
Public recognition (e.g., signage on property, stewardship banquets and awards, etc.)	☐	☐	☐	☐	☐	☐
Concern over loss of wetlands in this region	☐	☐	☐	☐	☐	☐
More information on how the decline in wetland area affects them personally	☐	☐	☐	☐	☐	☐
Access to technical assistance and information	☐	☐	☐	☐	☐	☐
If neighbours undertook this type of practice	☐	☐	☐	☐	☐	☐
A one-time payment to offset initial cost of enhancement or restoration	☐	☐	☐	☐	☐	☐
A small annual payment to acknowledge their environmental service provision to society and to help cover loss of revenue	☐	☐	☐	☐	☐	☐
Other (please specify): ________________________________	☐	☐	☐	☐	☐	☐

Section 4: Incentives for Enhancing & Restoring Wetlands

Suppose that in an effort to enhance and restore wetlands within and adjacent to the Grand River watershed, the government offered a voluntary program that provided incentives (e.g., payments, public recognition) to landowners to set aside some of their lands. This land could be (i) converted to meadow or trees to help retain nearby wetlands; or (ii) converted directly into wetlands if appropriate.

PROGRAM CONDITIONS:

Participating landowners would:

- Sign a 5-year contract to enroll some of their land and receive annual payments (to help compensate for lost income & acknowledge provision of an environmental service to society).
- Have the opportunity to renew the contract, or transfer/terminate it if the land is sold.
- Enroll land that is in addition to existing commitments under government or non-government programs and legal requirements.
- Have a say in what type of land conversion activities are implemented (i.e. whether to convert land to meadow, trees, or wetlands). All capital/material costs would be paid for by the government (on top of any financial incentive to you).

We would now like to ask you to evaluate several program options.

On each of the next few pages, you'll be presented with a set of 2 voluntary programs considered by the government. We ask you to choose between PROGRAM A, PROGRAM B, or NO PROGRAM.

PROGRAM CHARACTERISTICS:

Each program is described by the following range of PROGRAM CHARACTERISTICS:

Type of land to be converted	➡ land can be Productive or Marginal (i.e., less fertile) farmland
Conversion activity	➡ land can be converted to Meadow, Trees, or Wetland
Number of acres	➡ area converted can be 1, 3, or 5 acres
Public recognition	➡ can be Yes or No, depending on whether or not **signage** on property, stewardship **banquets**, & **awards** are provided.
Annual payments to you	➡ can be $50 to $550 per acre per year (to help compensate you for any lost income and to acknowledge your provision of an environmental service to society).

Please consider the options carefully - as if you were entering into a real contract with the government - since the program would have a limited budget and could only fund a limited number of projects.

SET 1:

17a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Type of land to be converted	Marginal	Marginal	---
Conversion activity	Wetland	Meadow	---
Number of acres	5 acres	3 acres	---
Public recognition	Yes	No	---
Annual payments to you	$450/acre	$450/acre	$0/acre
Please choose only one	☐	☐	☐

17b. On a scale 1 to 10, how certain are you about the program choice you made above?

Please circle the number that best represents your answer if ***1 equals not at all certain*** *and* ***10 equals very certain****.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

SET 2:

18a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

Program Characteristics	Program A	Program B	No Program
Type of land to be converted	Productive	Marginal	---
Conversion activity	Trees	Trees	---
Number of acres	3 acres	5 acres	---
Public recognition	Yes	No	---
Annual payments to you	$250/acre	$150/acre	$0/acre
Please choose only one	☐	☐	☐

18b. On a scale 1 to 10, how certain are you about the program choice you made above?

Please circle the number that best represents your answer if ***1 equals not at all certain*** *and* ***10 equals very certain****.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

SET 3:

19a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Type of land to be converted	Productive	Marginal	---
Conversion activity	Meadow	Wetland	---
Number of acres	1 acre	1 acre	---
Public recognition	Yes	No	---
Annual payments to you	$150/acre	$550/acre	$0/acre
Please choose only one	☐	☐	☐

19b. On a scale 1 to 10, how certain are you about the program choice you made above?

Please circle the number that best represents your answer if ***1 equals not at all certain*** *and* ***10 equals very certain****.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

SET 4:

20a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Type of land to be converted	Marginal	Productive	---
Conversion activity	Trees	Meadow	---
Number of acres	1 acre	3 acres	---
Public recognition	No	Yes	---
Annual payments to you	$350/acre	$50/acre	$0/acre
Please choose only one	☐	☐	☐

20b. On a scale 1 to 10, how certain are you about the program choice you made above?

*Please circle the number that best represents your answer if **1 equals not at all certain** and **10 equals very certain**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

<u>SET 5</u>:

21a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Type of land to be converted	Marginal	Marginal	---
Conversion activity	Meadow	Trees	---
Number of acres	5 acres	5 acres	---
Public recognition	No	Yes	---
Annual payments to you	$50/acre	$350/acre	$0/acre
Please choose only <u>one</u>	☐	☐	☐

21b. On a scale 1 to 10, how certain are you about the program choice you made above?

*Please circle the number that best represents your answer if **<u>1 equals not at all certain</u>** and **<u>10 equals very certain</u>**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

<u>SET 6</u>:

22a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Type of land to be converted	Productive	Productive	---
Conversion activity	Wetland	Wetland	---
Number of acres	3 acres	1 acre	---
Public recognition	No	Yes	---
Annual payments to you	$550/acre	$250/acre	$0/acre
Please choose only <u>one</u>	☐	☐	☐

22b. On a scale 1 to 10, how certain are you about the program choice you made above?
*Please circle the number that best represents your answer if **<u>1 equals not at all certain</u>** and **<u>10 equals very certain</u>**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

23. If you chose “NO PROGRAM” for any of the previous sets, please check the box that best explains why you chose this option. *Please check **one** box only.*

“The annual payments were too low”	☐
“I believe these projects would lower my property value”	☐
“The amount of land involved was too large”	☐
“The amount of land involved was too small”	☐
“I do not think retaining or restoring wetlands is an important issue”	☐
“The 5-year contract length was too restrictive”	☐
“I don’t trust the government”	☐
Other: ____	☐

24. If you chose either “PROGRAM A” or “PROGRAM B” for any of the previous sets, please check the box that best explains why you chose this option.

*Please check **one** box only.*

“The annual payments were the main reason for my choices”	☐
“We should restore wetlands regardless of the payment levels”	☐
“The public recognition of my conservation effort was the main reason for my choices”	☐
“It’s equally important to provide payments and recognition to landowners who restore wetlands in my area”	☐
Other: ____	☐

25. If you chose either “PROGRAM A” or “PROGRAM B” for any of the previous sets, please check the box that indicates your preferred renewable contract length.

*Please check **one** box only.*

☐ 1 year ☐ 10 years ☐ 20 years
☐ 5 years ☐ 15 years ☐ More than 20 years

Section 5: Your Personal Characteristics

26. What is your gender?

☐ Female ☐ Male

27. In what year were you born? __________

28. What is the highest level of education that you have completed?
*Please check **one** box only.*

☐ Elementary school ☐ Post-secondary (diploma or bachelor's degree)
☐ High school ☐ Graduate or professional degree (e.g. law, MD, masters, or PhD)

29. Which of the following best describes your present employment status?
*Please check **one** box only*.

☐ Working full time ☐ Retired ☐ Student
☐ Working part time ☐ Unemployed

30. Are you a member of any of the following types or organizations or associations?
*Please check **all** boxes that apply.*

☐ Environmental/conservation ☐ Farmer
☐ Hunting/fishing ☐ Woodlot
☐ ATV/snowmobile ☐ Other: ____________________________

31. What is your best estimate of your total household income (before taxes) over the past 12 months? *Please check **one** box only.*

☐ Less than $10,000 ☐ $30,000 to $49,999 ☐ $75,000 to $99,999
☐ $10,000 to $29,999 ☐ $50,000 to $74,999 ☐ More than $100,000

32. What percentage of your household income is from on-farm sources (i.e. crop / livestock)?

☐ 0 % ☐ 1 to 24 % ☐ 25 to 49 % ☐ 50 to 74 % ☐ 75 to 99 % ☐ 100 %

33. What is your postal code and rural route number (example: RR 1)?

Postal Code: ___________ Route Number: ___________

34. How would you describe your household's debt load? *Please check **one** box only.*

☐ Debt free ☐ Low ☐ Moderate ☐ High

End of Survey. Thank You!

Please place the completed survey in the postage-paid envelope and drop it off in the mail.

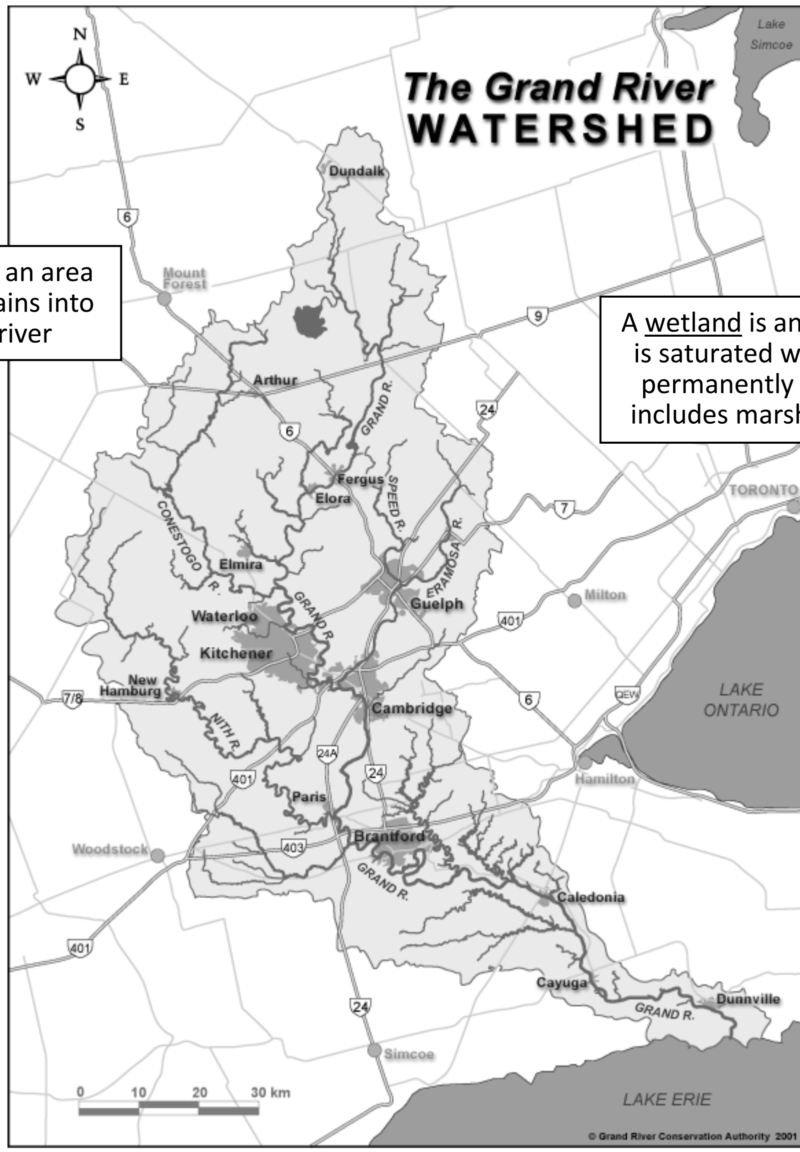
To be entered into the draw for one of three $100 Visa gift cards, please fill out the ballot at the bottom of the cover letter, detach, and return it with your completed survey.

Non-Farm Rural Landowner Focussed Choice Experiment

Survey of Landowner Views on Wetland Enhancement and Restoration in & near the Grand River Watershed

A watershed is an area of land that drains into a common river

A wetland is an area of land that is saturated with water, either permanently or seasonally. It includes marshes and swamps.



When you have completed this survey, please place it in the postage-paid envelope provided in your survey package and drop it off in the mail. Thank you!

Section 1: Your Land

1. Which county or municipality do you live in? *Please check **one** box only.*

☐ Dufferin County ☐ Regional Municipality of Waterloo
☐ Wellington County ☐ Oxford County
☐ Haldimand County ☐ Brant County
☐ Perth County ☐ Other (Please specify): ______________________

2. What is the total area of land that you own <u>inside</u> and <u>outside</u> the Grand River watershed (if needed, consult the map on the back of the cover letter)?
Please indicate the number of acres in the spaces provided.

Inside: ________ Acres
Outside: ________ Acres

3. When did you first obtain land in the region? *Please check **one** box only.*

☐ Before 1970 ☐ 1981-1990 ☐ 2001-2006 ☐ Not Applicable
☐ 1970-1980 ☐ 1991-2000 ☐ 2007-2013

4. What is the primary use of the land you own? *Please check **one** box only.*

☐ Agriculture ☐ Residence
☐ Forestry ☐ Other: _________________________________

5. If you generated income from your land over the past 5 years, is it from any of the following? *Please check **all** boxes that apply.*

☐ Farming ☐ Leasing land for recreation ☐ Not applicable
☐ Forestry ☐ Leasing land for farming or forestry ☐ Other: _____________
☐ Leasing land for hunting ☐ Development/sale of your land _____________

6. What will likely happen to your land after you retire? *Please check **one** box only.*

☐ Sell ☐ Give to land trust ☐ Have not started planning for retirement
☐ Give to family ☐ Don't know ☐ Other: _____________________________

7. People own land for many different reasons. How important are each of the following reasons to you? *For each reason, please check the box that corresponds with your answer.*

	Very important	Important	Neither important or unimportant	Of little importance	Un-important	Don't know
To make a living (farm, forest, or other income)	☐	☐	☐	☐	☐	☐
To complement my income	☐	☐	☐	☐	☐	☐
As an investment for future gain	☐	☐	☐	☐	☐	☐
As a location for my permanent residence	☐	☐	☐	☐	☐	☐
For recreation (hunting, fishing, walking, etc.)	☐	☐	☐	☐	☐	☐
To maintain a family legacy	☐	☐	☐	☐	☐	☐
For the sake of our future generations	☐	☐	☐	☐	☐	☐
To preserve ecosystems	☐	☐	☐	☐	☐	☐

8. Which of the following features do you have on your land?
Please check ***all*** *boxes that apply.*

☐ Crop ☐ Pasture ☐ Meadows
☐ Orchard ☐ Forests ☐ Other: ________________________

9a. Do you have wetlands on your land?

☐ Yes ➡ *If yes, please continue with question* ***9b***
☐ No ➡ *If no, please skip to question* ***10***

9b. Did you create, or have you enhanced, any of these wetlands? *Check* ***all*** *boxes that apply.*

☐ Created them ☐ Enhanced them ☐ No

9c. If you created or enhanced any wetlands on your land, please explain what you did and how it was funded. *If you answered 'No' to question* ***9b*** *please skip to question* ***10****.*

____

____

____

Section 2: Your Land Management

17. How many acres of your land are currently left untilled or dedicated to other land cover types, and how have these areas changed since 2006?

Please indicate your answers using the spaces provided below. For any specific land cover type that does not apply to your situation, please leave the associated space blank.

Land cover type	# of acres now	Change since 2006: Increase (acres)	Change since 2006: Decrease (acres)
Land left untilled	________	________	________
Fence line	________	________	________
Wind break	________	________	________
Trees	________	________	________
Shrub land meadow	________	________	________
Ditch	________	________	________
Wet area / Wetland	________	________	________
Other conservation measure: __________________________ __________________________	________	________	________

18. Have you ever received financial incentives or cost-share payments from any of the following programs for implementing conservation measures on your land?

*Please check **all** boxes that apply.*

- ☐ Stewardship Program offered by the local Conservation Authority
- ☐ Environmental Farm Plan
- ☐ I have not received financial assistance from any program
- ☐ Ducks Unlimited Wetland Retention or Restoration Programs
- ☐ Other: ____________________________________ ____________________________________

19. To what extent do you agree or disagree with each of the following statements about your landowner rights?

For each statement, please check the box that corresponds with your answer.

As a landowner, I have the **right** to…	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
…restrict others' access to my land	☐	☐	☐	☐	☐	☐
…transfer ownership of my land to others without restriction	☐	☐	☐	☐	☐	☐
…do whatever I want with my land without regard for others	☐	☐	☐	☐	☐	☐
…do anything with my land as long as my actions do not infringe upon neighbours' rights	☐	☐	☐	☐	☐	☐
…do anything with my land as long as my actions do not conflict with the interests and values of the local community	☐	☐	☐	☐	☐	☐

20. To what extent do you agree or disagree with each of the following statements about your landowner responsibilities?

For each statement, please check the box that corresponds with your answer.

As a landowner, I have the **responsibility** to…	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
… be a good steward of my land and to maintain it in a good condition for future generations	☐	☐	☐	☐	☐	☐
… leave the land in a better condition than when I acquired it	☐	☐	☐	☐	☐	☐
… take into account the values and interests of society at large when making decisions about my land	☐	☐	☐	☐	☐	☐

Section 3: Wetland Management

Information: Wetland Benefits

Wetlands in your area provide a number of benefits to the community, including:

- ***Water quality:*** Wetlands help purify water.
- ***Flood, drought, and erosion control:*** Wetlands help control flooding and erosion, as well as reduce the impacts of drought.
- ***Wildlife habitat:*** Wetlands provide habitat for native and/or endangered plant and wildlife species (both on land and in water).
- ***Carbon storage:*** Wetlands store carbon helping to slow climate change.
- ***Recreation and education:*** Wetlands provide recreational and educational

21. How important are the following wetland benefits in your area to you?
*Please check **one** box per item.*

	Very important	Somewhat important	Not important	No opinion
Water quality	☐	☐	☐	☐
Flood, drought, and erosion control	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Carbon storage	☐	☐	☐	☐
Recreation and education	☐	☐	☐	☐

22. How would you describe the current state of wetlands in your area?
*Please check **one** box per item.*

	Excellent	Good	Fair	Marginal	Don’t know
Quantity (amount) of wetlands	☐	☐	☐	☐	☐
Quality (health) of wetlands	☐	☐	☐	☐	☐
Accessibility to view wetlands	☐	☐	☐	☐	☐

Information: Decline in Wetland Area

- The area of wetlands in and around the Grand River watershed has declined significantly over the past century, largely due to human activities such as expansion of urban areas, agriculture, and industrial developments.
- While the rate of wetland loss has recently slowed, the area and/or quality of wetlands in your region still declines each year, resulting in further loss of wetland benefits.
- Landowners can help reverse the declining trend by enhancing existing wetlands and restoring previously drained ones on the land they manage.

23. In your opinion, what would motivate landowners in your region to participate in wetland enhancement and restoration activities on their land?
For each incentive, please check the box that corresponds with your answer.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
Public recognition (e.g., signage on property, stewardship banquets and awards, etc.)	☐	☐	☐	☐	☐	☐
Concern over loss of wetlands in this region	☐	☐	☐	☐	☐	☐
More information on how the decline in wetland area affects them personally	☐	☐	☐	☐	☐	☐
Access to technical assistance and information	☐	☐	☐	☐	☐	☐
If neighbours undertook this type of practice	☐	☐	☐	☐	☐	☐
A one-time payment to offset initial cost of enhancement or restoration	☐	☐	☐	☐	☐	☐
A small annual payment to acknowledge their environmental service provision to society	☐	☐	☐	☐	☐	☐
Other (please specify): ________________________________	☐	☐	☐	☐	☐	☐

Section 4: Incentives for Enhancing & Restoring Wetlands

Suppose that in an effort to enhance and restore wetlands within and adjacent to the Grand River watershed, the government offered a voluntary program that provided incentives to landowners to set aside some of their lands. The incentives would include public recognition, technical assistance, and/or annual payments to acknowledge their provision of an environmental service to society. The land could be converted from manicured lawns, old fields, or other to: (i) meadow or trees to help retain nearby wetlands; or (ii) wetlands if appropriate.

PROGRAM CONDITIONS:

Participating landowners would:

- Sign a 5-year contract to enroll some of their land and receive incentives (i.e., public recognition, technical assistance, and/or annual payments).
- Have the opportunity to renew the contract, or transfer/terminate it if the land is sold.
- Enroll land that is in addition to existing commitments under government or non-government programs and legal requirements.
- Have a say in what type of land conversion activities are implemented (i.e. whether to convert land to meadow, trees, or wetlands). All planting/restoration costs would be paid for by the government (on top of any financial incentive to you).

We would now like to ask you to evaluate several program options.

On each of the next few pages, you'll be presented with a set of 2 voluntary programs considered by the government. We ask you to choose between PROGRAM A, PROGRAM B, or NO PROGRAM.

PROGRAM CHARACTERISTICS:

Each program is described by the following range of PROGRAM CHARACTERISTICS:

Conversion activity	➡ land can be converted to Meadow, Trees, or Wetland
Number of acres	➡ area converted can be 0.5, 1, or 1.5 acres
Technical assistance	➡ can be Yes or No, depending on whether or not **technical experts** from the government or other groups are involved.
Public recognition	➡ can be Yes or No, depending on whether or not **signage** on property, stewardship **banquets**, & **awards** are provided.
Annual payments to you	➡ can be \$0 to \$250 per year (positive amounts acknowledge your provision of an environmental service to society).

Please consider the options carefully - as if you were entering into a real contract with the government - since the program would have a limited budget and could only fund a limited number of projects.

SET 1:

17a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Wetland	Meadow	---
Number of acres	1.5 acres	1 acre	---
Technical assistance	No	No	---
Public recognition	Yes	No	---
Annual payments to you	$200/year	$200/year	$0/year
Please choose only one	☐	☐	☐

17b. On a scale 1 to 10, how certain are you about the program choice you made above?

*Please circle the number that best represents your answer if **1 equals not at all certain** and **10 equals very certain**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

<u>SET 2</u>:

18a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Trees	Trees	---
Number of acres	1 acre	1.5 acres	---
Technical assistance	Yes	Yes	---
Public recognition	Yes	No	---
Annual payments to you	$50/year	$100/year	$0/year
Please choose only <u>one</u>	☐	☐	☐

18b. On a scale 1 to 10, how certain are you about the program choice you made above?

*Please circle the number that best represents your answer if **<u>1 equals not at all certain</u>** and **<u>10 equals very certain</u>**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

SET 3:

19a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Meadow	Wetland	---
Number of acres	0.5 acres	0.5 acres	---
Technical assistance	Yes	No	---
Public recognition	Yes	No	---
Annual payments to you	$50/year	$250/year	$0/year
Please choose only one	☐	☐	☐

19b. On a scale 1 to 10, how certain are you about the program choice you made above?
*Please circle the number that best represents your answer if **1 equals not at all certain** and **10 equals very certain**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

SET 4:

20a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Trees	Meadow	---
Number of acres	0.5 acres	1 acre	---
Technical assistance	No	Yes	---
Public recognition	No	Yes	---
Annual payments to you	$150/year	$0/year	$0/year
Please choose only one	☐	☐	☐

20b. On a scale 1 to 10, how certain are you about the program choice you made above?

Please circle the number that best represents your answer if ***1 equals not at all certain*** *and* ***10 equals very certain****.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

<u>SET 5</u>:

21a. If the following program options were the only ones available to you, which one would you choose?

Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Meadow	Trees	---
Number of acres	1.5 acres	1.5 acres	---
Technical assistance	No	No	---
Public recognition	Yes	No	---
Annual payments to you	$0/year	$150/year	$0/year
Please choose only <u>one</u>	☐	☐	☐

21b. On a scale 1 to 10, how certain are you about the program choice you made above?

*Please circle the number that best represents your answer if **<u>1 equals not at all certain</u>** and **<u>10 equals very certain</u>**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

SET 6:

22a. If the following program options were the only ones available to you, which one would you choose?
Please check the box that corresponds with your answer.

PROGRAM CHARACTERISTICS	PROGRAM A	PROGRAM B	NO PROGRAM
Conversion activity	Wetland	Wetland	---
Number of acres	1 acre	0.5 acres	---
Technical assistance	Yes	Yes	---
Public recognition	No	Yes	---
Annual payments to you	$250/year	$100/year	$0/year
Please choose only one	☐	☐	☐

22b. On a scale 1 to 10, how certain are you about the program choice you made above?
*Please circle the number that best represents your answer if **1 equals not at all certain** and **10 equals very certain**.*

1	2	3	4	5	6	7	8	9	10
Not at all certain				Somewhat certain					Very certain

23. If you chose "NO PROGRAM" for any of the previous sets, please check the box that best explains why you chose this option. *Please check **one** box only.*

"The annual payments were too low"	☐
"I believe these projects would lower my property value"	☐
"The amount of land involved was too large"	☐
"The amount of land involved was too small"	☐
"I do not think retaining or restoring wetlands is an important issue"	☐
"The 5-year contract length was too restrictive"	☐
"I don't trust the government"	☐
Other: ____	☐

24. If you chose either "PROGRAM A" or "PROGRAM B" for any of the previous sets, please check the box that best explains why you chose this option.

*Please check **one** box only.*

"The annual payments were the main reason for my choices"	☐
"We should restore wetlands regardless of the payment levels"	☐
"The public recognition of my conservation effort was the main reason for my choices"	☐
"It's equally important to provide payments and recognition to landowners who restore wetlands in my area"	☐
Other: ____	☐

25. If you chose either "PROGRAM A" or "PROGRAM B" for any of the previous sets, please check the box that indicates your preferred renewable contract length.

*Please check **one** box only.*

☐ 1 year ☐ 10 years ☐ 20 years
☐ 5 years ☐ 15 years ☐ More than 20 years

Section 5: Your Personal Characteristics

26. What is your gender?

☐ Female ☐ Male

27. In what year were you born? __________

28. What is the highest level of education that you have completed?
*Please check **one** box only.*

☐ Elementary school ☐ Post-secondary (diploma or bachelor's degree)
☐ High school ☐ Graduate or professional degree (e.g. law, MD, masters, or PhD)

29. Which of the following best describes your present employment status?
*Please check **one** box only*.

☐ Working full time ☐ Retired ☐ Student
☐ Working part time ☐ Unemployed

30. Are you a member of any of the following types or organizations or associations?
*Please check **all** boxes that apply.*

☐ Environmental/conservation ☐ Farmer
☐ Hunting/fishing ☐ Woodlot
☐ ATV/snowmobile ☐ Other: ____________________________

31. What is your best estimate of your total household income (before taxes) over the past 12 months? *Please check **one** box only.*

☐ Less than $10,000 ☐ $30,000 to $49,999 ☐ $75,000 to $99,999
☐ $10,000 to $29,999 ☐ $50,000 to $74,999 ☐ More than $100,000

32. What percentage of your household income is from on-farm sources (i.e. crop / livestock)?

☐ 0 % ☐ 1 to 24 % ☐ 25 to 49 % ☐ 50 to 74 % ☐ 75 to 99 % ☐ 100 %

33. What is your postal code and rural route number (example: RR 1)?

Postal Code: ___________ Route Number: ___________

34. How would you describe your household's debt load? *Please check **one** box only.*

☐ Debt free ☐ Low ☐ Moderate ☐ High

End of Survey. Thank You!

Please place the completed survey in the postage-paid envelope and drop it off in the mail.

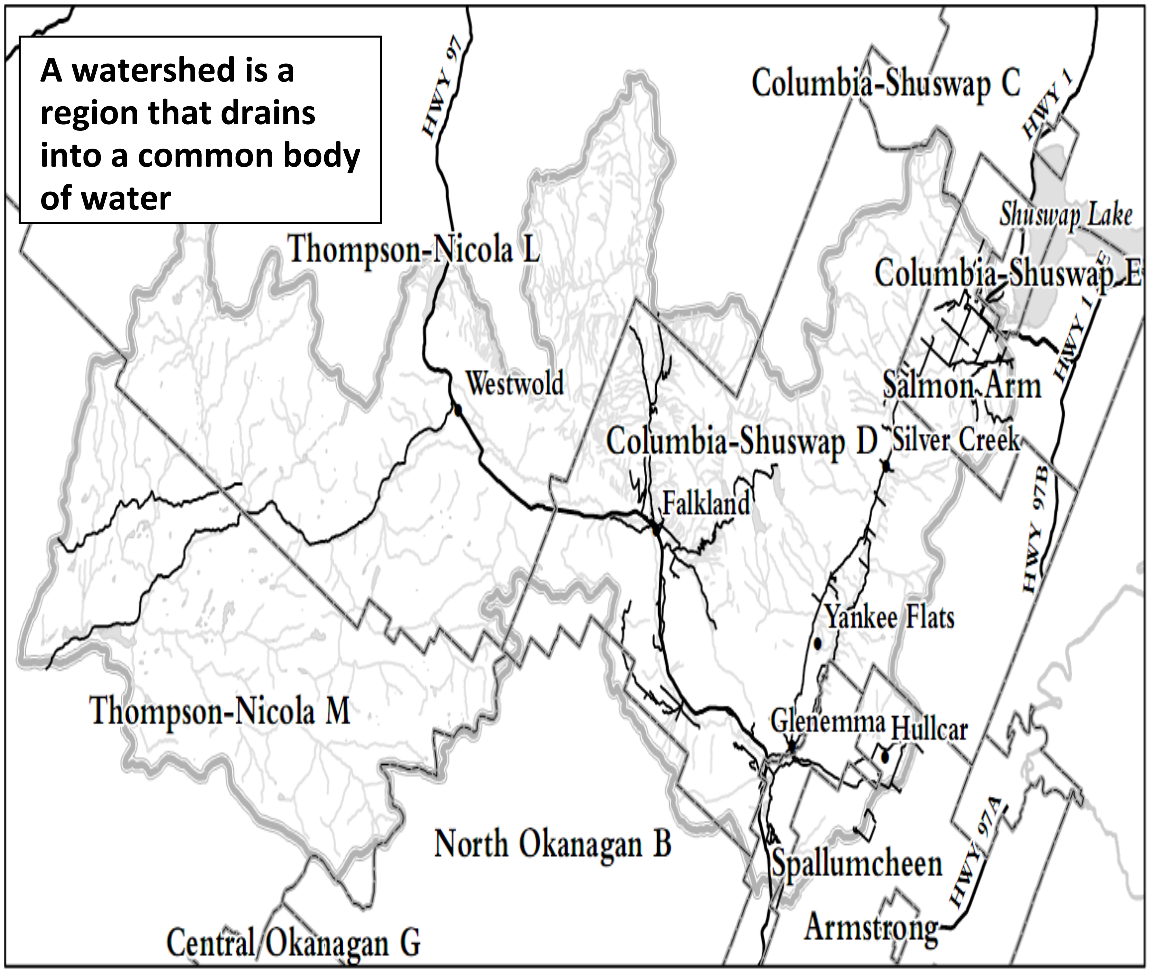
To be entered into the draw for one of three $100 Visa gift cards, please fill out the ballot at the bottom of the cover letter, detach, and return it with your completed survey.

Appendix F.

Public Benefits Choice Experiment Questionnaire

The questionnaire used in the Salmon River watershed is presented in this appendix. The questionnaires used in the other three watersheds were similar, though differed in terms of the map used on the cover page as well as the watershed names. Furthermore, as outlined in Chapter 5 the levels used for the wildlife habitat attribute differed across watersheds. The Salmon survey also included two extra questions about water use not included in the other watershed questionnaires that were of interest to other researchers in the Salmon watershed (questions 35 and 36).

Survey of Public Views on the Environment in the Salmon River Watershed, BC



The watershed boundary is represented by the thick grey line

When you have completed this survey, please place it in the postage-paid envelope provided in your package and drop-off in the mail. Thank you!

Section 1: Your Watershed

1. Where do you live in relation to the Salmon River watershed?
Please refer to the map on the back of the letter to help you answer this question, and check one box only.

Within watershed ☐ Outside watershed ☐ I don't know ☐

2. Do you own a farm or a woodlot in the region?
Please check the box that corresponds with your answer.

Farm ☐ Farm and Woodlot ☐
Woodlot ☐ Neither ☐

3. Are you a member of any of the following types of organizations or associations?
Please check all boxes that apply.

Environmental/conservation ☐ ATV/snowmobile ☐
Hunting/fishing ☐ Farm commodity producer ☐
Landowner ☐ Forestry producer ☐

4. Over the past 12 months have you participated in any of the following outdoor activities within the Salmon River Watershed? *Please check all that apply.*

Hunting	☐	Swimming	☐	Snowshoeing	☐
Fishing	☐	Boating	☐	X-Country Skiing	☐
Camping	☐	Berry/Mushroom picking	☐	Snowmobiling	☐
Biking	☐	Bird watching	☐	Other Motor Sports	☐
Running/Walking/Hiking	☐	Horseback riding	☐	Other	☐

5. In your opinion, how important is it to have each of the following in your watershed region? *For each item, please check the box that corresponds with your answer.*

	Very important	Important	Neither important or unimportant	Of little importance	Unimportant	Don't know
Flood/Drought prevention	☐	☐	☐	☐	☐	☐
Soil erosion control	☐	☐	☐	☐	☐	☐
Carbon sequestration	☐	☐	☐	☐	☐	☐
Good water quality	☐	☐	☐	☐	☐	☐
Soil fertility for farming/forestry	☐	☐	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐	☐	☐
Visually pleasing landscapes	☐	☐	☐	☐	☐	☐
Large diversity of plants and animals	☐	☐	☐	☐	☐	☐

Section 2: Your Opinion on Land Management and Land Use Within the Salmon River Watershed

The following questions are about your opinion on landowners and their land use in the watershed. Landowners are people who own at least 10 acres of land and include farmers, woodlot owners, and people who own their land for other reasons.

6. To what extent do you agree or disagree with each of the following statements?
For each statement, please check the box that corresponds with your answer.

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	Don't know
Private land should provide for the needs of future plant and animal populations	☐	☐	☐	☐	☐	☐
What landowners do on their own land affects people aside from their family	☐	☐	☐	☐	☐	☐
What landowners do today on their land will matter in the long run	☐	☐	☐	☐	☐	☐
Landowners should work together if it means the land would be better off	☐	☐	☐	☐	☐	☐
There is too much government regulation of private land use	☐	☐	☐	☐	☐	☐
Individual properties are unimportant in the big picture of all the land in the region	☐	☐	☐	☐	☐	☐
Rare or endangered species should be protected on private land	☐	☐	☐	☐	☐	☐
Private land provides benefits to society	☐	☐	☐	☐	☐	☐
Sensitive areas on private land should be protected from being altered or damaged	☐	☐	☐	☐	☐	☐
I am aware of my rights with respect to my legal use of other people's land	☐	☐	☐	☐	☐	☐

7. **To what extent do you agree or disagree with each of the following statements?**
For each statement, please check the box that corresponds with your answer.

Landowners have a responsibility to…	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	Don't know
… be good stewards of their land and to maintain it in a good condition for future generations	☐	☐	☐	☐	☐	☐
… leave the land in a better condition than when they acquired it	☐	☐	☐	☐	☐	☐
… take into account the values and interests of society at large when making decisions about their land	☐	☐	☐	☐	☐	☐

8. **To what extent do you agree or disagree with each of the following statements?**
For each statement, please check the box that corresponds with your answer.

Landowners have the right to…	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	Don't know
…restrict others access to their land	☐	☐	☐	☐	☐	☐
…transfer ownership of their land to others without restriction	☐	☐	☐	☐	☐	☐
…do whatever they want with their land without regard for others	☐	☐	☐	☐	☐	☐
…do anything with their land so long as their actions do not infringe upon neighbours' rights	☐	☐	☐	☐	☐	☐
…do anything with their land so long as their actions do not conflict with the interests and values of the local community	☐	☐	☐	☐	☐	☐

9. Do you feel the public should be able to use private land for each of the following activities? *Please check one box per item.*

	Yes, it is the public's right	**Yes**, but only with landowner permission	**No**, this use should not be allowed
Walking	☐	☐	☐
Hunting	☐	☐	☐
Gathering berries, mushrooms, etc. for personal use	☐	☐	☐
Gathering berries, mushrooms, etc. for commercial use	☐	☐	☐
Operating recreational motorized vehicles	☐	☐	☐
Accessing water for recreational purposes	☐	☐	☐
Camping	☐	☐	☐

10. To what extent do you agree or disagree with each of the following statements?
For each statement, please check the box that corresponds with your answer.

Landowners should be primarily responsible for…	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
Protecting wetlands from being altered or damaged	☐	☐	☐	☐	☐	☐
Providing wildlife habitat	☐	☐	☐	☐	☐	☐
Reducing the use of fertilizers	☐	☐	☐	☐	☐	☐
Retaining trees in areas vulnerable to soil erosion	☐	☐	☐	☐	☐	☐
Protecting woodlots from being cleared	☐	☐	☐	☐	☐	☐
Reducing the use of pesticides	☐	☐	☐	☐	☐	☐
Establishing watercourse buffers	☐	☐	☐	☐	☐	☐
Providing public access to land for recreation	☐	☐	☐	☐	☐	☐

11. Are there any activities or actions that you would like to be able to prevent landowners in the watershed from doing on their own land?
If so, please write them in the space provided below.

Section 3: Your Perspective on the State of the Salmon River Watershed

The Salmon River watershed provides many environmental, social, and economic services. These include fresh water, wildlife habitat, and farm/woodlot owner incomes among others.

However, some citizens are concerned that recent trends in economic activity are threatening the watershed's ability to supply these services.

12. In your opinion, how would you describe the current state of the watershed in terms of each of the statements below? *Please check one box per item.*

	Excellent	Good	Fair	Marginal	Don't know
Water quality is:	☐	☐	☐	☐	☐
Wildlife habitat is:	☐	☐	☐	☐	☐
Recreation opportunities are:	☐	☐	☐	☐	☐
Farm/Woodlot owner incomes are:	☐	☐	☐	☐	☐

14. How concerned are you about the future state of the watershed in terms of the following aspects? *Please check one box per item.*

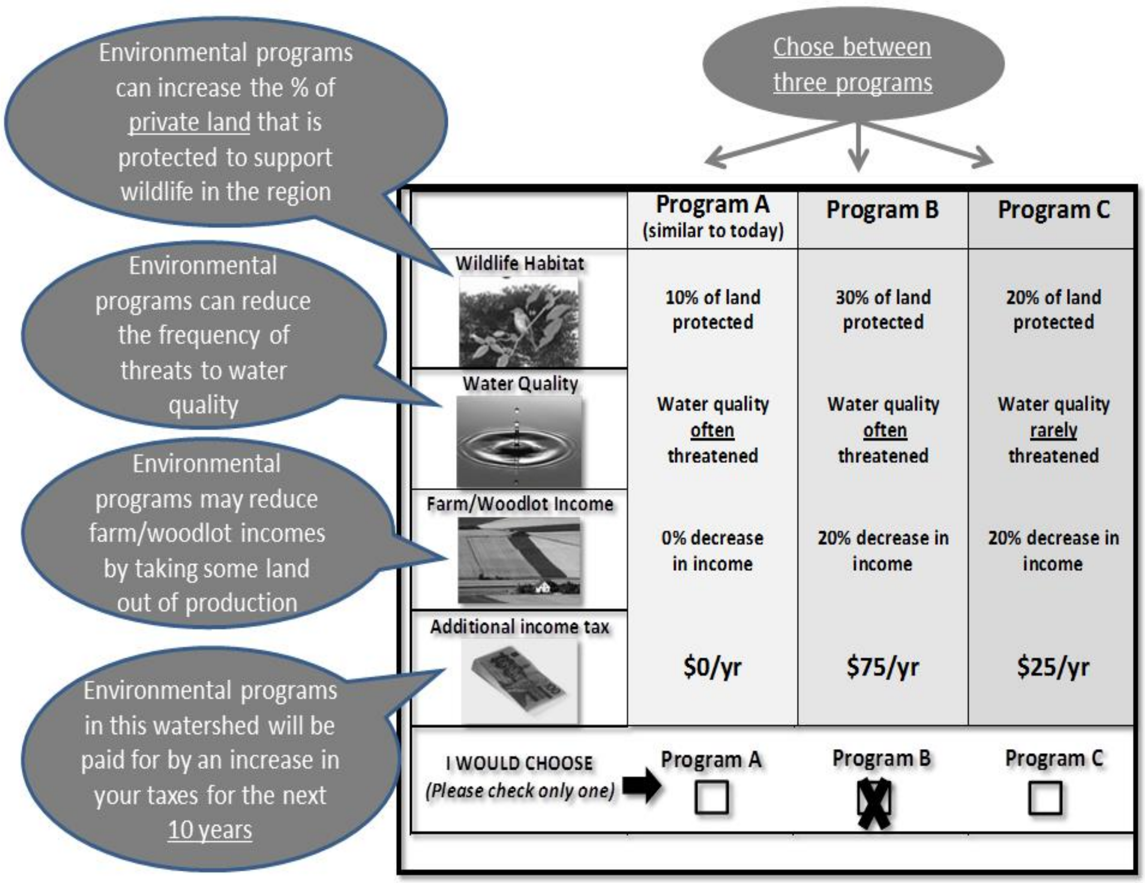
	I'm very concerned	I'm somewhat concerned	I'm not concerned	No opinion
Water quality:	☐	☐	☐	☐
Wildlife habitat:	☐	☐	☐	☐
Recreation opportunities:	☐	☐	☐	☐
Farm/Woodlot owner incomes:	☐	☐	☐	☐

Section 4: Your Preferences for Environmental Stewardship Programs in the Salmon River Watershed

Environmental conditions in the watershed can be maintained and/or improved through various government-funded environmental stewardship programs.

On the following pages, we will ask you to choose between different programs that would improve environmental conditions <u>10 years from now</u> in the watershed. Each question will ask you to choose 1 of 3 environmental stewardship programs: A, B, or C.

<u>Example</u>:



Please assess each of the following 6 Choice Sets and choose your preferred option.

Consider each set independently and imagine that you would have to actually dig into your household budget and pay the additional taxes.

CHOICE SET 1:

15. If Programs A, B, and C below were the only ones available in the watershed, which one would you choose?
Please check the box that corresponds with your answer.

	Program A (similar to today)	Program B	Program C
Wildlife Habitat 	10% of land protected	30% of land protected	10% of land protected
Water Quality 	Water quality <u>often</u> threatened	Water quality <u>often</u> threatened	Water quality <u>rarely</u> threatened
Farm/Woodlot Income 	0% decrease in income	20% decrease in income	20% decrease in income
Additional income tax 	$0/yr	$75/yr	$25/yr
I WOULD CHOOSE *(Please check only one)*	Program A ☐	Program B ☐	Program C ☐

15. How certain are you about the program choice you made above?

☐ Certain ☐ Somewhat Certain ☐ Somewhat Uncertain ☐ Uncertain ☐ Don't Know

CHOICE SET 2:

16. If Programs A, B, and C below were the only ones available in the watershed, which one would you choose?
Please check the box that corresponds with your answer.

	Program A (similar to today)	Program B	Program C
Wildlife Habitat 	10% of land protected	20% of land protected	10% of land protected
Water Quality 	Water quality <u>often</u> threatened	Water quality <u>rarely</u> threatened	Water quality <u>sometimes</u> threatened
Farm/Woodlot Income 	0% decrease in income	10% decrease in income	0% decrease in income
Additional income tax 	$0/yr	$25/yr	$50/yr
I WOULD CHOOSE *(Please check only one)* ➡	Program A ☐	Program B ☐	Program C ☐

17. How certain are you about the program choice you made above?

☐ Certain	☐ Somewhat Certain	☐ Somewhat Uncertain	☐ Uncertain	☐ Don't Know

CHOICE SET 3:

18. If Programs A, B, and C below were the only ones available in the watershed, which one would you choose?
Please check the box that corresponds with your answer.

	Program A (similar to today)	Program B	Program C
Wildlife Habitat 	**10% of land protected**	**20% of land protected**	**30% of land protected**
Water Quality 	**Water quality <u>often</u> threatened**	**Water quality <u>sometimes</u> threatened**	**Water quality <u>rarely</u> threatened**
Farm/Woodlot Income 	**0% decrease in income**	**20% decrease in income**	**0% decrease in income**
Additional income tax 	**$0/yr**	**$100/yr**	**$200/yr**
I WOULD CHOOSE ***(Please check only one)*** ➡	**Program A** ☐	**Program B** ☐	**Program C** ☐

19. How certain are you about the program choice you made above?

☐ Certain ☐ Somewhat Certain ☐ Somewhat Uncertain ☐ Uncertain ☐ Don’t Know

<u>CHOICE SET 4</u>:

20. If Programs A, B, and C below were the only ones available in the watershed, which one would you choose?
Please check the box that corresponds with your answer.

	Program A (similar to today)	**Program B**	**Program C**
Wildlife Habitat 	10% of land protected	20% of land protected	20% of land protected
Water Quality 	Water quality <u>often</u> threatened	Water quality <u>often</u> threatened	Water quality <u>often</u> threatened
Farm/Woodlot Income 	0% decrease in income	0% decrease in income	20% decrease in income
Additional income tax 	$0/yr	$50/yr	$200/yr
I WOULD CHOOSE *(Please check only one)* ➡	Program A ☐	Program B ☐	Program C ☐

21. How certain are you about the program choice you made above?

☐ Certain ☐ Somewhat Certain ☐ Somewhat Uncertain ☐ Uncertain ☐ Don't Know

CHOICE SET 5:

22. If Programs A, B, and C below were the only ones available in the watershed, which one would you choose?
Please check the box that corresponds with your answer.

	Program A (similar to today)	Program B	Program C
Wildlife Habitat 	**10% of land protected**	**10% of land protected**	**30% of land protected**
Water Quality 	**Water quality often threatened**	**Water quality often threatened**	**Water quality sometimes threatened**
Farm/Woodlot Income 	**0% decrease in income**	**20% decrease in income**	**0% decrease in income**
Additional income tax 	**$0/yr**	**$25/yr**	**$75/yr**
I WOULD CHOOSE ***(Please check only one)***	**Program A** ☐	**Program B** ☐	**Program C** ☐

23. How certain are you about the program choice you made above?

☐ Certain	☐ Somewhat Certain	☐ Somewhat Uncertain	☐ Uncertain	☐ Don't Know

CHOICE SET 6:

24. If Programs A, B, and C below were the only ones available in the watershed, which one would you choose?
Please check the box that corresponds with your answer.

	Program A (similar to today)	Program B	Program C
Wildlife Habitat 	10% of land protected	20% of land protected	30% of land protected
Water Quality 	Water quality <u>often</u> threatened	Water quality <u>sometimes</u> threatened	Water quality <u>often</u> threatened
Farm/Woodlot Income 	0% decrease in income	10% decrease in income	10% decrease in income
Additional income tax 	$0/yr	$75/yr	$150/yr
I WOULD CHOOSE *(Please check only one)*	Program A ☐	Program B ☐	Program C ☐

25. How certain are you about the program choice you made above?

☐ Certain ☐ Somewhat Certain ☐ Somewhat Uncertain ☐ Uncertain ☐ Don't Know

26. If you chose Program A (similar to today) as an answer for <u>any</u> of the Choice Sets 1 to 6 above, why did you choose so?

Please check <u>the one</u> explanation that most affected your choices above

"The increase in annual income taxes was too high"	☐
"I think tax money could be better spent on other issues"	☐
"I do not have enough information to make this decision"	☐
"The proposed environmental changes were unrealistic"	☐
"I do not think the environment is an important issue"	☐
"I don't trust the government"	☐
Other: ____ ____	☐

27. If you chose either Program B or C as an answer for <u>any</u> of the Choice Sets 1 to 6 above, why did you do so?

Please check <u>the one</u> explanation that most affected your choices above

"I think that this is a small price to pay for the environmental improvements"	☐
"I think we should protect the environment regardless of the cost"	☐
"It is important to invest in protecting the environment for future generations"	☐
"I think our government does not do enough to protect our environment"	☐
"I feel it is the 'right thing' to do"	☐
Other: ____ ____	☐

Section 5: Your Personal Characteristics

This section will assist us with our statistical analysis. Responses to these questions and all other questions will be treated anonymously.

28. What is your gender?

Female ☐ Male ☐

29. In what year were you born? *Please indicate the year in the space provided below.*

____

30. What is the highest level of education that you have completed?
Please check one box.

31.

Elementary school ☐ Post-secondary (diploma or bachelors degree) ☐
High school ☐ Graduate university degree (Masters or PhD) ☐

31. How would you best describe the place where you grew up and the place where you have lived most of your adult life?
Please check one box only for each item below.

	Urban	Suburban	Rural
Where I grew up:	☐	☐	☐
Where I have lived most of my adult life:	☐	☐	☐

32. Which of the following best describes your present employment status?
Please check one box only.

Working full time ☐ Not currently working ☐
Working part time ☐ Retired ☐

33. What is your best estimate of your total household income over the past 12 months?
Please check one box only.

Less than $10,000 ☐ $30,000 to $49,999 ☐ $75,000 to $99,999 ☐
$10,000 to $29,999 ☐ $50,000 to $74,999 ☐ More than $100,000 ☐

34. Where were you born?
Please check one box only.

Born in Canada ☐
Not born in Canada ☐ ➔ **In what year did you arrive in Canada?**

____

35. Do you use any of following water saving devices?
Please check all that apply.

Low flow faucets	☐	Efficient sprinkler nozzles	☐
Low flow toilets	☐	Water meter	☐

Other: ______________________________________ ☐

36. To what extent do you agree or disagree with each of the following statements?
For each statement, please check the box that corresponds with your answer.

Landowners who irrigate their fields…	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	Don't know
…use water efficiently	☐	☐	☐	☐	☐	☐
…use water efficiently to improve stream and river flows	☐	☐	☐	☐	☐	☐
…use water efficiently to improve their own crops	☐	☐	☐	☐	☐	☐

Comments:

End of Survey, Thank You!!