Estimating the Economic Value of Improving the Ecological Condition of the Saskatchewan River Delta Ecosystem

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ABSTRACT

This research aims to quantify how much Canadians are willing to pay to improve the ecological condition of the Saskatchewan River Delta (SRD). The research develops and administers a stated preference survey that focuses on non-use values for changes in important ecological endpoints (lake sturgeon population levels, muskrat abundance, habitat in healthy ecological condition, and waterfowl population levels). A second objective of this research is to understand if values differ across provinces, age range, income levels and other socio-economic characteristics.

Results suggest that Canadians are willing to pay for the improvement of the delta ecological condition. Estimated marginal willingness to pay values range from \$1.55 - \$2.53 for a 1% improvement in the level of the ecological attributes. Overall habitat in healthy ecological condition is the most preferred SRD ecological attribute. Taken together, the annual economic benefits to Canadian households for various SRD restoration scenarios is estimated to be \$104 to \$223 for 20 years. From a policy perspective, the study provides credible economic values for the benefits associated to the restoration of SRD and suggests that there can be a level of confidence that valid non-use values for river deltas in Canada do, in fact, exist and can be quantified.

The results also indicate that Canadians have diverse values for SRD restoration. Some of this preference heterogeneity can be attributed to people's income level, age category, education level, employment status, gender, and province of residence. Explained preference heterogeneity with respect to a few of socio-demographic characteristics provides insight into the social demand for the Delta restoration. Decision-makers and public managers can then use this knowledge and information on the sources of heterogeneity to improve SRD restoration.

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Chapter 1: INTRODUCTION

1.1 Background

With a landmass of 9.1 million square kilometres, Canada is the second largest country on earth, occupying roughly the northern two-fifths of the continent of the North America. Canada is recognized as one of the five countries that contain 70% of the world's remaining wilderness (Watson et al., 2018) and holding a capacity to supply ecosystem services greater than the global average (Rice et al., 2018). Yet, Canada is one of the world's most sparsely populated countries, with almost 80 per cent of the country's land being uninhabited. In 2016, 66% of Canadians lived clustered within 100 kilometres of the southern Canada-United States border, which accounts for only 4 per cent of the country's total land area (Key Results from the 2016 Census, 2017).

The fact that the Canadian population is not distributed uniformly throughout Canada's territory should not indicate that ecosystem services in less populated areas do not have an economic value. Moreover, economic values Canadians put on ecosystems should not be limited to only those captured through market transactions or those that require a physical involvement of citizens with certain characteristics. If this is the case, the true full economic value that Canadians attribute to the country's ecosystems risks being underestimated and not accurately captured.

Indeed, empirical evidence, although limited, shows that the wide array of benefits that Canadians derive from ecosystems, quantified through the concept of ecosystem services (Finlayson et al., 2005; Nichols et al., 2018), go beyond the use values derived directly from the current users to the expected future use of a certain aspect of the ecosystems (Bishop et al., 1987). Canadians also assign values to the ecosystem's continued existence and conservation, independent from its use(s) or possible use(s) (National Conservation Survey Research Report, 2017; Wright et al., 2019). Eighty-five percent of Canadians are concerned about the risk of natural areas' destruction and degradation while seventy-five percent of Canadians perceive the country's natural areas preservation as important in order to protect plants and animals at risk and leave nature as a legacy for our children (Ipsos Reid, 2011).

Use and non-use values of ecosystems are not mutually exclusive. From an economic perspective, it is possible for an individual to hold both categories of values (use and non-use values) which differ in terms of the requirement for a current or future human interaction with some aspect of the ecosystem. It is commonly agreed that these two main types of values are additive components of the total economic value of most environmental goods. The former refers to those values associated with the current or future use of an ecosystem and are derived from physical involvement with some aspect of it, such as fishing, hiking, or farming (Bishop et al., 1987). On the contrary, non-use values, usually attributed to the work by Krutilla (1967), do not require a physical interaction with any aspect of the ecosystem and arise solely from the continued existence of the resource (Adamowicz et al., 1998; Freeman III et al., 2014). For instance, these values may reflect the intangible human satisfaction of leaving a park, watershed, or a river behind for future generations.

Many of the methods of valuation that rely on economic procedures fail to capture non-use values as a component of the full range of economic values of ecosystems contributing to people’s well-being (Haluza-DeLay et al., 2009). Non-use values are not easily reconciled with marginal changes in resource quantity or quality (Carson & Navarro, 1988). This makes it challenging to quantify values people place on non-use functions of environmental goods and attributes and infer the marginal impact of changes in their provision levels on people’s behaviours as consumers (Langford et al., 2001). That is particularly present in the Canadian context considering the above-mentioned reasons.

Despite the challenges in quantifying non-use values, this component of the total economic value has been a part of the environmental economics field for decades and extremely prevalent in federal agency economic analysis procedures. Non-use values are recognized by the Government of Canada as a valid component of economic analysis (Treasury Board of Canada Secretariat, 2007) and it has also been discussed to include non-use values in Canadian court cases addressing the compensation for environmental damages to public natural resources (Ingelson, 2019).

The importance of estimating non-use values is highlighted in sorting through river delta restoration strategies that compete for scarce funding. These restoration strategies aim to reverse the most prominent anthropogenic impacts in a river delta caused by the alteration of upstream water flows and degradation of the ecosystem. But, for the changes to the river delta ecosystem to happen, a long period of time is typically required. As such, it is anticipated that non-use type values associated with such restoration strategies are significant.

This is because of their key attribute of being independent of direct or indirect use(s) of the delta ecosystems by the individual. Not recognizing the associated non-use values can lead to misjudgement and understatement of the true value of economic benefits of river delta restoration. In addition, missing the information on the non-use values of the restoration strategy, might lead to the selection of a strategy that does not provide the greatest benefits to the society as a whole.

1.2 Research objectives

Significant ecosystem services of natural areas in Canada are not traded in monetary markets, making it challenging to quantify their economic value. In particular, there is limited evidence on the estimation of non-use values associated with restoring river deltas in Canada. The primary purpose of this thesis is to highlight the importance of valuing non-use values in this context, by focusing on putting an economic value to the non-use values derived by ecosystem services of the Saskatchewan River Delta (SRD), the largest freshwater inland delta in North America. Benefits derived by the SRD's ecosystems extend far beyond extensive human activities sustained such as hunting, fishing, recreation, tourism, and trapping. The SRD is of a particular ecological significance because the area supports a large amount of biodiversity and is home to several at-risk plants, birds, and mammals, which makes it an important case study to answer the objectives.

Specific questions answered in this research will be:

1. Whether and to what extent are Canadians willing to pay for the SRD restoration even in the absence of actual, planned or possible use?
2. How do various socio-economic characteristics of Canadians' influence their willingness to pay for the SRD restoration?

In order to answer these research questions, a stated preference survey is designed, tested and implemented. The stated preference approach is considered necessary in this research context because this approach is the only non-market valuation method capable of estimating non-use benefits (Dupont et al., 2010). The survey was administered to a representative sample of the Canadian population in terms of province of residence, age range, and gender and asks respondents to answer a series of trade-off questions involving SRD restoration scenarios with different environmental and monetary outcomes.

The choice data generated from the survey are used to conduct both descriptive and econometric analyses to answer the research questions. Several discrete choice models are estimated in consistency with the Random Utility Theory Framework (McFadden, 1974) to understand Canadians' preferences for the restoration of SRD and demonstrate the link between people's preferences and their individual-specific characteristics.

Non-use values associated with the SRD improvement of ecological condition are measured in monetary units of individuals' willingness to pay (WTP), very common in stated preference approaches for determining the amount of money that individuals are willing to pay to use, improve or restore ecosystem services or natural resources (Brauman et al., 2007; Nicosia et al., 2014). In this study, WTP is associated with a change in the provision level of carefully selected ecological indicators. Although the primary interest of the research is to provide welfare estimates on the benefit side of the restoration of the SRD, the research aims to also provide a rough qualitative overview of the wide range of costs associated with its restoration and highlight the need for further research in this aspect.

This thesis is composed of six chapters. In the next chapter, the current state of SRD, potential threats, and conservation opportunities are presented to support its selection as the study site to address the research objectives. Chapter three provides a discussion of relevant literature on the development of non-market valuation methods and a few examples of Canadian and US studies addressing non-use values of ecosystems and their services. After providing the context for this study, chapter four starts with a presentation of the conceptual framework used to estimate the willingness to pay for various SRD restoration scenarios. That is followed by a thorough discussion of the stated preference survey development and implementation process in order to provide evidence of rigour in the design of this instrument. Chapter five presents and discusses the results of the analysis – in particular willingness to pay for various levels of SRD restoration differing in terms of improvement levels of ecological indicators and how preferences are influenced by various socio-economic characteristics. Finally, chapter six provides a brief discussion of a few of potential uses of the study results and implications as well as limitations of the research and recommendations made for further research.

Chapter 2: SASKATCHEWAN RIVER DELTA

2.1 Introduction

This chapter briefly provides a definition of river deltas as a landscape and hydrological feature and then outlines the ecological significance of the Saskatchewan River Delta as a unique ecosystem, followed by a detailed description of SRD's benefits, its current state, potential threats and conservation opportunities. The information provided in this chapter establishes the background necessary to understand the selection of the SRD as the study site to address the research objectives.

River deltas are freshwater landforms or low-lying plains formed when a fast-moving river flows into another comparatively slower-moving, low-energy large body of water such as lake or ocean basin. The formation of a river delta is a protracted process dependent on a decrease of the flow rate of the river in order for the river to deposit the large amounts of sediment, silt, sand, and gravel particles suspended in the relatively rapidly moving river water. Over time, these suspended solids fall to the bottom of the river and deposit at the river's mouth where it meets the other body of water, building up to form the river delta.

Delta ecosystems comprise interlinked networks of river channels, wetlands, and tidal creeks, rich in land, water, and ecological resources, thus turning into a substantial source of benefits for the agriculture, industry, and commerce (Loucks, 2019). In their natural state, deltas are the by-product of remarkable bio geophysical balancing acts shaped and reshaped by natural forces (Vorosmarty et al., 2009). The inputs to deltas supplied by river channels such as minerals, freshwater, organic and inorganic materials stimulate and fertilize wetland plant growth, consequently supporting fish and wildlife. Moreover, sediments and nutrients serve as a hedge against sea-level rise through organic soil formation (Vorosmarty et al., 2009).

2.2 The Saskatchewan River Delta as a unique ecosystem and current threats

2.2.1 History of the SRD

The Saskatchewan River Delta (SRD) is the largest freshwater inland delta in North America and among the world largest contiguous wetlands, encompassing an area of approximately 1 million hectares. Originating over 10,000 years ago, at the end of the last ice age, SRD has evolved to a network of wetlands, waterways, and low-lying forests, located in the Mid-Boreal Lowland Ecoregion within the Saskatchewan River Basin, straddling the border of central Saskatchewan and Manitoba. The SRD is fed by both the North and South Saskatchewan River and is part of a watershed that spans across Saskatchewan, Manitoba, and Alberta (Figure 2-1). Geographically, the SRD consists of two parts-western and eastern-separated by a prominent moraine (The Pas Moraine), commonly termed the “upper delta”, located mainly in Saskatchewan and more than double size of the “lower delta”, located entirely in Manitoba east of the Pas. Fed by the South Saskatchewan and North Saskatchewan rivers draining much of Alberta and Saskatchewan provinces, this inland Delta is one of the most biologically rich landscapes in Canada (Morrison, 2012).

Figure 2-1 Location and extent of the SRD in Saskatchewan and Manitoba and main hydroelectric dams (adapted from Andrews et al., 2018)

Note: Dams are shown in stars

The SRD has played an important economic and environmental role to local Indigenous communities (Abu, 2017; Casey, 2013). The SRD is home to the oldest continuously occupied settlement in Saskatchewan - Cumberland house, and has provided sustenance to Indigenous people since its formation. For a long time after the establishment of the first European settlement at Cumberland House in 1774, the delta has played a vibrant role in the international fur trade enterprise for the Hudson Bay Company in North America. Today, SRD is home to approximately 15,000 people, either in communities including Cumberland House, Opaskwayak Cree Nation, and The Pas, or isolated in remote areas (Watchorn, 2011).

SRD wetlands account for approximately 80% of the total delta area. The SRD supports a variety of large and small mammals, including moose *(Alces alces)*, beaver *(Castor Canadensis)* and muskrat *(Ondatra zibethicus)*, as well as myriad plants, and 48 species of fish (Abu, 2017). The waterways are home to lake sturgeon (*Aciperser fulvescens*) currently listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and is under consideration for listing under the Species at Risk Act (COSEWIC, 2017; McLeod et al., 1999).

The delta is also recognized internationally as a Canadian Important Bird Area due to the significant role it plays as a breeding ground and a stopover location for over 200 species migratory birds, in particular for the waterfowl within the Central and Mississippi flyways (Asante et al., 2017; Wells et al., 2014). According to Canadian Wildlife Service and U.S Fish and Wildlife Service, on average approximately 500,000 ducks nest in the SRD each year (Watchorn, 2011).

2.2.2 Upstream threats to the SRD

The SRD faces many direct threats largely caused by human interventions occurring upstream in the Saskatchewan River Basin (Schindler & Donahue, 2006) which have disrupted its entire ecosystem. These impacts have unequivocal consequences for delta's health, physiography, hydrology and biological diversity (Abu et al., 2020; Irland, 2017).

Upstream activities have greatly disrupted the natural functioning of the delta for decades and negatively affected its ecological integrity. Examples of such upstream activities include the construction of nineteen hydroelectric dams (Baschuk, 2010), with the three large ones considered the Gardiner Dam, E.B. Campbell Dam (EBC), and the Francois Finley Dam *(shown in Figure 2-1)*. Additionally, continuous development of farmland allocated mainly in the southern part of Saskatchewan, urban development and water diversion for urban, industrial, and irrigation purposes has taken place upstream of the delta (Abu, 2017). These activities have caused irregular flooding patterns characterized by rapid changes in water levels, unnatural major floods, and holding spring and summer water back, negatively affecting its capacity to support the abundance of wildlife, plants and species. For the past 100 years, annual water flow discharge from the Saskatchewan River through the SRD have decreased 20 percent resulting in reduced 'natural' flood frequency (Patrick & Baijius, 2021).

Additionally, farmland and urban development have long affected the delta downstream through the waste and chemicals released into the Saskatchewan river system.

Water allocation policies in Saskatchewan relevant to the SRD are based on water availability from water resource systems in the Saskatchewan River basin, demand conditions, water allocation priorities and system physical properties (Kulshreshtha et al., 2012). Higher water allocation priorities are given to municipal sector and irrigated agriculture followed by hydropower and other sectors (Saskatchewan's State of the Environment, 2021). While the water supply from the Saskatchewan River Basin currently meets demands (i.e. supply drinking water to cities, supply crops with water for irrigation, hydropower, etc.), it is adding to the causes of delta deterioration. Moreover, demand for water supply for household, industrial, and agricultural purposes from the Saskatchewan rivers is predicted to continue to increase due to accelerating economic growth, expanding population, and climate change impacts (Kulshreshtha et al., 2012). This constant increasing demand is further reducing flow to the SRD, which in return is affecting the entire food chain, ultimately resulting in an out-of-balance ecosystem (Sagintayev et al., 2015).

Agricultural irrigation, the largest consumptive water use from the South Saskatchewan River (SSRWS, n.d.), considerably affects the peak flows in the SRD (Hassanzadeh et al., 2015). Additionally, the projected[1] $4 billion irrigation expansion provincial project based out of Lake Diefenbaker upstream of the SRD risks an increase in agricultural contaminants flowing downstream and reduction of the water flow entering the Delta (Abirhire et al., 2022). All that would ultimately devastate the delta region (Warick, 2020). Moreover, water quality in the SRD has worsened because of the drainage of pesticides and other toxins into the delta by upland agricultural and municipal areas (Irland, 2017).

Hydrologic developments on the Saskatchewan River have changed the flow regimes of the river and affected the hydrology of the downstream SRD wetlands. One major impact is the reduction of the water flow peaks in the spring and summer because of the dams retaining much of the water for sustained power generation (Figure 2-2). Another concerning impact is the creation of unnatural patterns of extreme changes in river discharge coming into the delta because of the EBC dam's hydropeaking - the discontinuous release of turbined water due to peaks of energy demand (Figure 2-3).

[1] Announced by the provincial government in July, 2020.

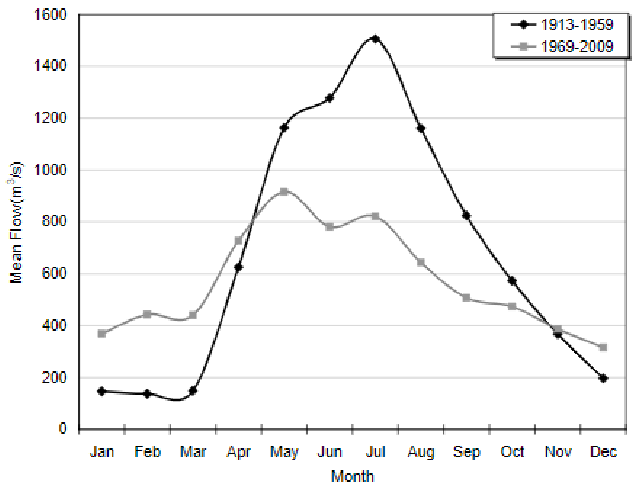

Figure 2-2 Comparison of mean monthly flow (m^3/s) of the Saskatchewan River, measured at the Pas, Manitoba, Canada before and after dam construction in 1969 (Source: Baschuk, 2010)

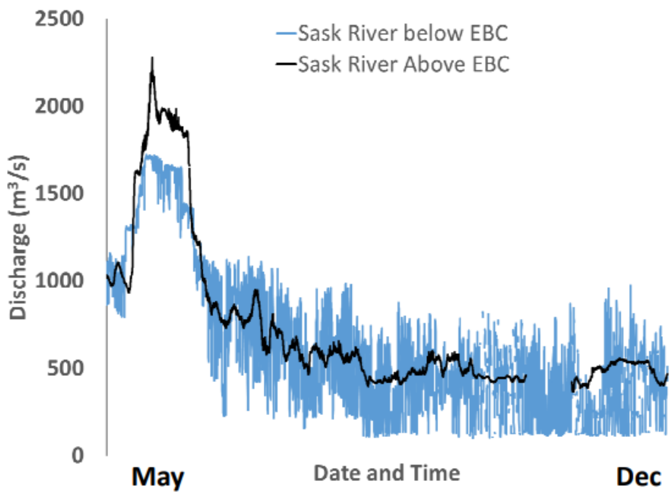

Figure 2-3 Comparison of seasonal and daily fluctuations in river discharge above (black line) and below the E.B. Campbell dam (blue line) from June to December 2014. (Source: Andrews et al., 2018)

Note: Figure shows the E.B. Campbell's degree of influence on river flows after accounting for upstream control structures. These daily fluctuations occur in both summer and winter with flows increasing and decreasing by as much as 700 m^3/s.

Decreased water flows into the delta, unnatural flow patterns, the sediment-deficiency and erosion in water downstream the dams have resulted in a less productive delta ecosystem and severe decline in the wildlife species that were once present (SRD Conservation Initiative, n.d). For instance, the construction of Grand Rapids Dam in the 1960s at the downstream end of the SRD, between Cedar Lake and Lake Winnipeg (as shown in Figure 2-1), permanently flooded about 10,000 ha of wetlands and associated upland habitat in the lower part of the SRD (Baschuk et al., 2012; Ervin, 2011). Additionally, beaver and muskrat populations, have significantly declined due to freezing and flooding effects of water fluctuations (Andrews et al., 2018). Similarly, long-term data from aerial surveys for the period 1955-2009 show a decrease in the total number of waterfowl within the SRD during spring counts (Figure 2-4.

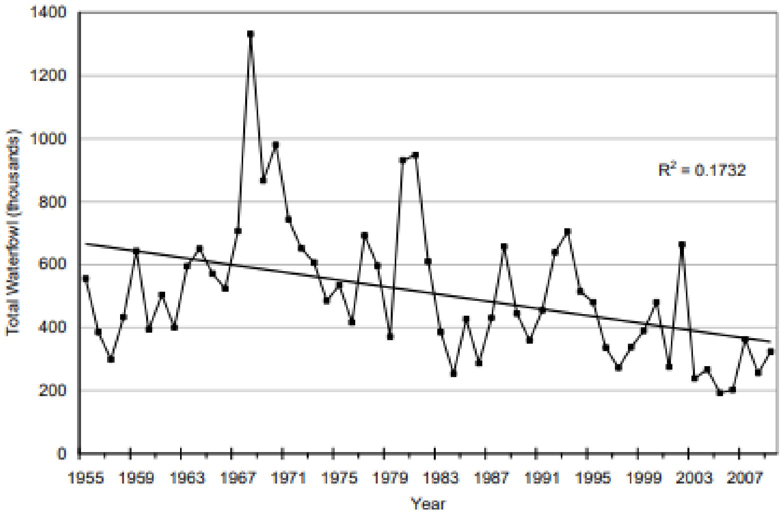

Figure 2-4 Total number of waterfowl counted in the SRD from 1955-2009 (Source: Baschuk, 2010)

Note: Trend line indicates an overall decrease in waterfowl numbers.

Lake Sturgeon[2], one of Canada's most recognizable and largest freshwater species (Scott & Crossman, 1973), has declined by 80% in the Cumberland House area, Saskatchewan from 1960 – 2001 and by 50% from Cumberland House to the Pas in Manitoba (Lake Sturgeon COSEWIC Assessment Summary, 2006). Scarcity of suitable food and low

[2] Lake sturgeon is classified as endangered species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Species at Risk Public Registry, Government of Canada).

water temperatures associated with cold-water releases from Gardiner Dam have made the 100 km reach immediately downstream this dam unsuitable for Lake Sturgeon habitat (COSEWIC, 2017).

Significant loss of wildlife in the SRD such as waterfowl, muskrat, and moose has negatively impacted the Opaskwayak Cree Nation (OCN) and other First Nations communities, which have traditional territory located within the Delta (Abu, 2017; Abu & Reed, 2018; Morrison, 2012). These communities have historically used the wetlands located in the SRD as a source of subsistence through hunting, fishing and trapping. Moreover, the use of wetland ecosystems in the Delta as a place for the organization of traditional activities has given them a special cultural importance to the local communities.

2.3 Restoring and conserving the Saskatchewan River Delta

2.3.1 Restoration opportunities within the SRD

An increasing number of actions such as the water-control structures, numerous channels, fish ladders into two major SRD wetlands (built by DUC), as well as clearing waterways and management have been implemented periodically in the SRD to address the above mentioned impacts imposed on its ecology.

A few of the main stakeholders directly invested in conservation actions in the SRD are Ducks Unlimited Canada, Cumberland Cree House Nation, and Partners for Saskatchewan River Basin (PSFRB). In 2018, DUC funded and initiated a $1.5 million project to rebuild the water control structure on the South Reader outlet dam near The Pas, aiming to mitigate the negative effects of the Grand Rapids dam built in the 1960s. The rebuilt water control structure is estimated to maintain 260,000 acres (105,218 hectares) of wildlife habitat in the SRD (Ducks Unlimited Canada, 2019). In addition, Cumberland Cree House Nation has periodically undertaken conservation initiatives such as clearing waterways from log jams, dredging the Old Channel to help water travel towards the Cumberland Marshes, and advocating burning and controlling invasive plants. These efforts aim to return the natural water flow through the channels, provide habitat for the migratory species in the Delta, support muskrat and other species' habitat (CPAWS, Saskatchewan Chapter). PSFRB has undertaken conservation actions to mitigate the impact of increased agricultural and irrigation development on downstream water quality.

The Canadian Parks and Wilderness Society-Saskatchewan (CPAWS) in collaboration with the Cumberland House Cree Nation have proposed[3] the establishment of an Ecological Reserve near Cumberland House, SK. This project aims to conserve both SRD's biodiversity and protect traditional values for local communities (Canada Target 1 Challenge - Government of Canada, n.d.).

Also, it is to be noted the effort[4] done to complete a Ramsar[5] nomination for over 5,000km^2 of the SRD (CPAWS, Saskatchewan Chapter). A Ramsar Designation would give the Delta the additional international recognition and contribute to promoting responsible use of the Delta's wetlands, which represent more than 80 per cent of the total area (Casey, 2013).

The year 2021 marked a crucial moment in taking measures to protect and conserve the SRD. In June 2021, Cumberland House Cree Nation has declared environmental and economic jurisdiction and protection of the SRD (CPAWS, 2021), also known as the Kitaskīnaw, which is a first step in Indigenous-led protection of the Delta. The declaration is built upon a larger Treaty 5 declaration in accordance with the law on the sharing of lands and natural resources with the settler society. It gives Cumberland House Cree Nation the primary role in the conservation of ecosystems, restoration of the land and culture, as inseparable components, in alignment with the Government of Canada's Federal Adaptation Policy Framework (Molnar et al., 2021). Following the economic and ecological sovereignty over the delta by Cumberland House Cree Nation, in November 2021, the Lobstick Lake area, approximately 100,000 ha, which covers a part of the SRD south of Cumberland House, has been designated as an ecological reserve (Environment and Climate Change Canada, 2021). The ecological protection designation of Lobstick Lake reserve intends to promote the conservation of wildlife and wetlands in the area.

In addition to the actions described in this section, various other potential mitigation options are highlighted in the literature (Pollock, 2012; Watkinson et al., 2020). These

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[3] This project is one of the components of Canada Target 1 Challenge, an investment by the Canada federal government in projects that can add to Canada's protected and conserved areas across the country (Canada Target 1 Challenge - Government of Canada).

[4] This is done in collaboration between Cumberland House Cree Nation, Canadian Parks and Wilderness Society, Ducks Unlimited, and the University of Saskatchewan.

[5] The Ramsar Cnvention is formed in 1971 to designate specific wetlands as internationally important. The Ramsar criteria are based on rare, representative, or unique wetland types and conserving biological diversity. The Delta qualifies for first 8 of the 9 Ramsar criteria (Anhorn, n.d.).

options target restoring and/or maintaining natural flow conditions and aim to correct and/or prevent disruptions of damaged fish habitat, including Lake Sturgeon. However, additional research is needed to understand the costs associated with each recommended action and their feasibility.

2.3.2 Upstream conservation opportunities

In addition to direct restoration activities within the SRD, there are also upstream interventions that can help enhance the SRD ecosystems.

Alterations in the flow regime entering the SRD can affect delta's hydrographic networks and concentrations of nutrients and dissolved oxygen, which in turn, can affect the aquatic and terrestrial ecosystems. Flow regime in the SRD is considered to be more sensitive to upstream changes in annual flow volume than peak flow timing and/or irrigation expansion (Hassanzadeh et al., 2017). The sensitivity to changes in flow volume is intensified when combined with changes in peak timing as shifts in the upstream peak flow timing. As a result, it can alter the magnitude and timing of peak flow to the SRD.

Flow management may need to follow the natural hydrological cycle; to assess the amount, timing, and conditions under which water should be released (Bergkamp et al., 2000; Scruton & Ledrew, 1997). Timing of a flood release should consider both fish and fish habitat, as well as the SRD as shifts in peak flow timing can alter the magnitude and timing of flow to the delta, and increased rates of isolation of lakes and wetlands from the Saskatchewan River (Hassanzadeh et al., 2017). It is now recognized that flow prescriptions for ecological restoration must include resupplying sediment along with flow to restore natural channel and floodplain processes (Volke et al., 2015). Given the complexity of water management in terms of both infrastructure and jurisdictions, flow management may need to start in the headwaters (Alberta) and there would be impacts to other upstream users in both Alberta and Saskatchewan as well as downstream in Manitoba (Watkinson et al., 2020). Although controversial, dam removal is often argued as being associated with ecological restoration benefits that potentially offset the loss of hydroelectric production, water supply, and other important services (Roy et al., 2018). A series of decision alternatives are considered in the study of Roy et al. (2018): keep or remove the New England Dam, improve fish passage, improve existing hydropower capacity, and build new hydropower dams at candidate sites. Findings highlight the dam removal as the least expensive alternative. Total costs for this alternative were predicted to be 50% less than the costs of fish passage installation alternative and 82% less than the costs of new turbine installation alternative. Hence, the authors propose a combination of dam removals with investments in renewable energy sources and alternative water supply as a strategy to improve efficiency and reverse the ecological impact. The model used in this study is considered adaptable at some extent to identify how trade-offs shift with unique factors of a specific dam site and watershed, such as scale, location, criteria and feasibility of alternatives.

When evaluating the upstream opportunities to restore the delta, it must be noted that business-as-usual policies and priorities might not be able to accommodate water supply for expanded irrigation and other economic activities and at the same time meet downstream environmental needs under changing upstream flow conditions (Hassanzadeh, 2019). It is challenging to directly evaluate the impact of changing upstream conditions on downstream environmental needs in the SRD and additional research is required in this aspect.

2.3.3 Challenges associated with estimating costs of management actions to improve the ecological condition of the delta

In choosing a portfolio of management actions to improve the ecological condition of the Delta, two main considerations are key: (i) the action's ecological potential to support Delta's many ecological indicators and (ii) the costs to those using the SRD's lands and waters, including the various uses upstream.

It is beyond the scope of this study to collect primary data to fully identify and quantify all costs and ecological potential of different management actions. The limited secondary data on the economic values of resource use related directly or indirectly through the upstream activities, is generated years ago and cannot be directly used in today's context and thus need to be reassessed to incorporate the changes and shifts in water uses and economic development. What the study aims to point out though is the need for an extensive, complex, and iterative process with the engagement of different stakeholders and implementation of integrated models discussions, consultation with the literature, and additional research. Few of the challenges described below support this argument.

Variations in data sources and costs of carrying out primary research suggest that the specific measures and procedures used for estimation of the costs associated with SRD restoration might vary somewhat across management actions. In some cases, it might be possible for the cost estimates to reflect the direct expenditures required for implementation, but for some other management actions, especially for most of flow-related measures which imply reductions in human water diversions, the cost might instead reflect losses to water and land users whose activities would be constrained by new measures.

Past work has been done to understand the value of the Saskatchewan River for irrigation and other alternative uses in Saskatchewan and Alberta (Bruneau et al., 2007; Kulshreshtha et al., 1993; Kulshreshtha & Gillies, 1994; Samarawickrema & Kulshreshtha, 2008). Kulshreshtha et al. (2012) also attempt to predict how the water demand in the South Saskatchewan River Basin for the province of Saskatchewan will change until 2060. However, these predictions are made under a baseline scenario that assumes that trends based on past data will continue into the future, without being affected by climate change or any water conservation policy. Additionally, these studies were conducted a long time ago and value estimates are dated, thus raising questions for how relevant they are to use in a modern economic analysis. Therefore, up-to-date research is needed to reassess the estimates.

Broader impacts to hydropower, beyond annual cost of power production (cost of repair and maintenance) and total electricity production, need to be considered as well when evaluating management options that affect dam operations upstream of the delta. Similarly, although agricultural annual net benefits are primarily based on the annual cost of crop production in the area (cost of fertilizer, seeds), crop price, as well as crop yield, comparison of irrigation agriculture relative to dryland agriculture needs to be done as well, thus complicating the process. Additionally, there is still a lack of knowledge and a lot of uncertainties around the quantified effects of the hydropeaking operation of the E.B. Campbell dam on fish and fish habitat.

Findings from other river delta restoration studies cannot be directly transferred to our study site because of its unique characteristics and the provinces-related economic benefits associated with the upstream activities. The estimates generated by these studies are useful to the extent that they provide a general understanding and expectation of the magnitude range of the restoration costs (Medellín-Azuara et al., 2013).

In addition to those above-mentioned challenges, other factors needs to be taking into consideration when flashing out the details and selecting the optimal restoration strategy challenges. Examples include the need for information on the implementation experience of management programs within the Delta watershed and implications for the water right reallocations (Weber & Cutlac, 2014). As such, it is required to know what actions are already employed to some extents, what additional implementation is planned or being considered, and what actions are still at the conceptual stage and thus not yet sufficiently developed for active consideration.

An open question surrounding the feasibility of SRD restoration projects, a few of them described in this chapter, is who bears the financial costs. In this view, the results of this study can help understand if the broader Canadian public, beyond the local community, benefits from SRD conservation and is willing to pay for these activities. The results of this study can be used in the cost-benefit analysis to measure the broader benefits from different conservation opportunities of the SRD and evaluate their economic efficiency.

Chapter 3: NON-MARKET VALUATION

3.1 Introduction

This chapter outlines the establishment and growth of non-market valuation research and discusses studies estimating non-use values that have been conducted in Canada and in US. Furthermore, various design and implementation issues associated with the stated preference method are discussed. The combination of non-market valuation methods, a review of river delta valuation studies and a discussion of design issues surrounding stated preference research provides context for this study.

3.2 Non-market values and valuation methods

Economists use prices and quantities for goods traded in markets to understand their economic value. Nevertheless, just because some goods, mainly environmental goods and services, are not traded in markets, does not mean they do not have economic value for people. Although their economic value is not revealed in market prices, people would still value them and be willing to pay to improve their quality, increase quantity, or ensure they are available for future generations. For example, people might enjoy spending time in nature sites or derive happiness from the existence of natural ecosystems and wilderness areas. These types of values are denoted by the term ‘non-market’ values.

The category of non-market values that this study focuses on is non-use values, which do not require a physical interaction with any aspect of the ecosystem and arise solely from the continued existence of the resource (Adamowicz et al., 1998; Carson, 2000; Freeman III et al., 2014). Three types of non-use values are generally distinguished:

(i) existence values reflecting an individual’s valuation of the non-market good’s existence alone;

(ii) altruistic values gained by an individual from the knowledge that the good or service is being used by others;

(iii) bequest values reflecting the perceived value of conserving or preserving a good or service because of its cultural and natural heritage for future generations (Bertram & Rehdanz, 2013; Carson, 2000).

Few studies attempt to separate the non-use value components in practice due to the challenges in seeking greater precision on these components and accurately providing estimates on them (Fischhoff & Furby, 1988; Mcclelland et al., 1992) .

Research shows that the non-use values of a natural resource or ecosystem are most likely to be greater in magnitude when the resource is unique and when injuries or losses to the resource are irreversible (Harpman et al., 1993) or more difficult to be reversed, such as the case of Saskatchewan River Delta. Examples of non-use values include the value derived from preserving a river so that others can swim in it, even though you have no intention of ever doing so; the willingness to pay for excluding all uses of a river, so as to preserve its existence; or the value derived from preserving the landscape and species for future generations. As shown in Figure 3-1, non-use values are recognized to be an important component of the total economic value (TEV) that an individual derives from a natural resource, in addition to use values.

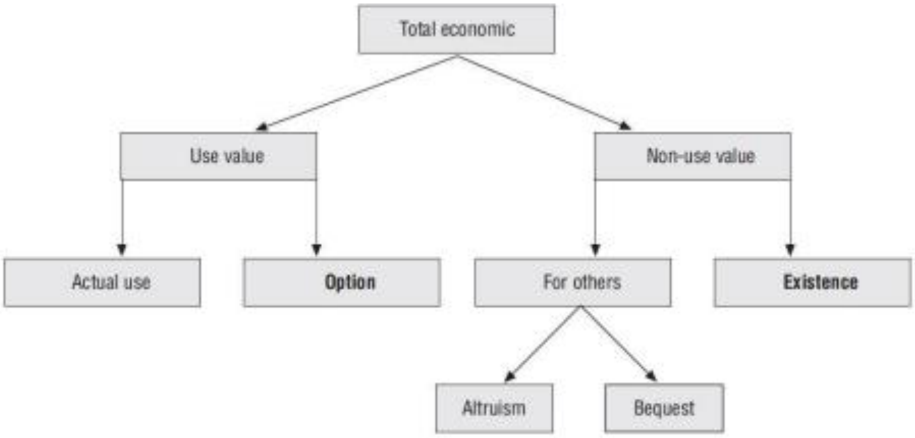

Figure 3-1 Non-use values as one of the main components of the total economic value (Source: Pearce et al., 2006)

There is a substantial applied and academic literature that documents the range of methods used to quantify, and monetize non-market values (Champ et al., 2003; Freeman III et al., 2014; Grafton et al., 2004; Haab & McConnell, 2002; Kanninen & Bateman, 2006). There are two broad categories of primary non-market valuation methods which differ fundamentally on the basis of the process through which people’s preferences for a non-market good or service is derived: revealed preference (RP) methods and stated preference (SP) methods (Adamowicz et al., 1994).

3.2.1 Overview of Revealed Preference Methods

The unifying characteristics of RP methods, which is considered their main strength as well, is the use of data on people's actual decisions to draw statistical inferences on values that people place on environmental goods and services (Freeman III et al., 2014). RP methods use information from markets associated with the nonmarket good being valued to infer values for the nonmarket good, since the market prices do not exist for them. Monetary estimates derived from the application of RP method tend to be easily accepted and adopted by economists when there exists a relationship between the use of a non-market good or service of interest and purchasing some market goods or service.

For instance, hedonic[6] wage models use market data to obtain differences in wages to measure wage premiums paid in exchange for higher risk jobs (Smith & Gilbert, 1985). The travel cost method uses the costs which people incur during their trip to a recreation site as a proxy of the value of the site (Haab & McConnell, 2002). Other RP methods, such as averting behaviour or cost of illness approach, typically focus on using the cost of replacing the service or treating the damages arising from loss of the services as a valuation approach. These two methods are typically used to value the benefits of health rather than in environmental economics.

Even though each of the RP approaches can be used to estimate value for nonmarket goods, the conceptual frameworks, data, and applications of each of the RP approaches differ essentially (Boyle et al., 2003), as described in Table 3–1. When determining which RP approaches are complementary or substitutes in a particular application and how many need to be combined, the first step is to identify the change to be valued and the affected group (Boyle et al., 2003). To date, the RP methods have been applied in a variety of contexts (Table 3-1, column 1) in non-market valuation of ecosystems (Agimass et al., 2018; Ahn et al., 2000; Alvarez et al., 2014; Bockstael et al., 1989; Bouwes & Schneider, 1979; P. C. Boxall, 1995; Haener & Adamowicz, 2011; Hanley et al., 2003). Examples of applications include estimating the demand for visits to a recreation site, measuring the health impacts of pollution, valuing recreational fishing in freshwater lakes and marine waters, or estimate the value of an environmental quality or ecosystem service that directly affects market prices for houses.

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[6] When this framework is applied, risk is treated as a job attribute that cannot be traded in a market.

Table 3-1 An overview of revealed preference methods and differences in terms of conceptual frameworks, data they use and applications

Method	**Revealed behavior**	**Conceptual framework**	**Types of application**
Hedonic pricing	Property purchased; choice of job	Demand for differentiated products	Property value and wage determinants
Travel cost	Participation in recreation activity at chosen site	Household production; complementary goods	Recreational demand
Averting behaviour/defensive expenditure	Time costs; purchases to avoid harm	Household production; substitute goods	Health: mortality and morbidity
Cost of illness	Expenditures to treat illness	Treatment costs	Health: morbidity

(Source: Champ et al., 2003)

RP methods do, however, have limitations when being used to provide monetary estimates for non-market goods in a policy analysis context. Their main strength is at the same time their main weakness. Because RP methods rely on market data and focus on observed past behaviour, they are limited to measuring only those environmental changes that are accompanied by a change in behaviour (Freeman III et al., 2014). Therefore, in the case when non-use values of an ecosystem that are non observed in real-world data need to be estimated, RP methods fail to do that (Baker & Ruting, 2014).

3.2.2 Overview of Stated Preference Methods

The limitations of RP methods in non-market valuations motivated the development of SP methods, which do not require the observation of actual behavior to infer monetary values of the non-market good or service being valued. SP methods go beyond estimating the use values of ecosystem services and can additionally elicit non-use values that individuals attach to ecosystem preservation and biodiversity (Adamowicz et al., 1994).

SP methods use surveys or structured conversations with people to elicit trade-offs and estimate welfare measures. Values of ecosystem services are inferred by asking them either to state a monetary amount to implement an improvement (management) program or choose between hypothetical programs consisting of better (improved) environmental outcomes (Baker & Ruting, 2014).

Because surveys are the vehicle by which the SP methods are implemented in empirical studies, generally the researcher has a greater control to shape the hypothetical scenarios to ask the trade-offs questions intended to be addressed compared to being limited to the available data found in actual markets (Adamowicz, Louviere, et al., 1998). At the same time, surveys being at the core of SP methods impose the need for the researcher to make a few considerations regarding the way in which the decision context is worded and presented to respondents, attributes and their levels selection, format of information presentation, and aspects of survey design experimentation (Adamowicz, Louviere, et al., 1998; Lloyd-Smith et al., 2020).

To date, SP methods have experienced significant development and improvement, with an increasing number of applications in various context. Their ability to produce non-market value estimates that are sufficiently reliable and valid to use in policy analysis is widely accepted. However, a major criticism of these methods remains the insufficient sensitivity to scope (Czajkowski & Hanley, 2009; Kahneman & Knetsch, 1992). This potential shortcoming implies that there might be a possibility that respondents are not willing more for a larger amount of an environmental good, in terms of increased quantity or quality. In addition, familiarity of respondents with the environmental good in question has an impact on how well SP methods can perform, considering that respondents cannot give accurate responses for unfamiliar goods as their preferences are not fully defined (Svedsäter, 2003).

The two most popular SP techniques are contingent valuation method and the discrete choice experiment (DCE) (Freeman III et al., 2014). The DCE is adopted in this study. As SP methods, both DCEs and contingent valuation use surveys to present respondents with a set of alternatives from which a single preferred option is expected to be selected. The choice responses are then used to estimate how much individuals are willing to pay for a non-market good and as such are similar in many ways. The average per-household or per-individual welfare estimates provided can be extrapolated to the wider population to provide an indication of the total societal non-market benefits or costs of a policy or program.

There are some important differences between contingent valuation and DCE approaches. Contingent valuation approach asks people their maximum willingness to pay or minimum compensation sums for hypothetical positive (or negative) changes in the environmental good (or service), valued as a whole (Mitchell & Carson, 1989). On the other side, DCE asks people to choose between different consumption bundles, described in terms of their attributes and the levels taken by these attributes (Hanley et al., 1998). Typically, one of the attributes is the price term.

According to Adamowicz et al. (1998), the ability of the DCE approach to provide an in depth and complete description of possible attribute trade-offs among the alternatives presented to respondents supports improved preference elicitation. In this context, DCE is considered to have an advantage compared to contingent valuation (Adamowicz et al., 1998; Hanley et al., 1998; Mitchell & Carson, 1989) because the researcher can infer four important pieces of information:

(i) which attributes significantly influence choice

(ii) the implied ranking of the attributes

(iii) the marginal WTP for an increase or decrease in any significant attribute

(iv) implied WTP for a programme, which changes more than one attribute simultaneously.

Careful consideration to the selection and combination of important attributes of the goods, service, or policy of interest is key for a successful DCE. There is always the danger of confusing and overburdening the respondents if the presented attributes are not a final product of careful planning and pretesting (Kanninen & Bateman, 2006). Ultimately, this approach contributes to a greater degree of provided information necessary for welfare measures compared to contingent valuation (Adamowicz et al., 1998).

3.3 Why it is important to account for non-use values in decision-making processes

An important benchmark in the history of non-use values significance is the 1989 Exxon Valdez oil spill in the northern part of the Gulf of Alaska, which was estimated to have had affected more than 1,300 km of coastline and killed almost 23,000 birds. A contingent valuation study used for the purpose of measuring lost non-use value as a result of the Exxon Valdez oil spill generated an estimate of $2.8 billion, which should be regarded as a lower bound on this damages (Carson et al., 2003; Kling et al., 2012). This amount represented the public’s median willingness to pay to prevent another Exxon Valdez type oil spill. Two precautious measures were taken in the scenario construction and sample selection, such as the exclusion of private services (i.e. commercial fishing) from the injury scenario and the exclusion of Alaskan households associated with direct use public services (i.e. recreational fishing) from the final sample. This process ensured that the value of $2.8 billion obtained from the study represents almost exclusively passive use value (Carson et al., 1992).

Another case that demonstrates the importance of non-use values in court decisions is the explosion of the Deepwater Horizon oil rig off the Gulf of Mexico Coast in 2010, which triggered economic, environmental devastation, and a legal battle. The study undertaken on behalf of the state of Louisiana, USA and NOAA (National Oceanic and Atmospheric Administration) estimated that the damage done by the spill to natural resources was $17.2 billion as opposed to only $700 million for recreation use values (Bishop et al., 2016). To put a dollar value on the natural resources damages by the BP Deepwater spill, a stated preference survey was developed and distributed on a national level. The payment vehicle was framed as a one-time tax the average household would be willing to pay for measures that would prevent similar damages should a spill of the same magnitude happen again in the future. The findings of this study highlighted that whereas the estimate of ecosystem services' non-use values per individual may not be significant, in this case $153/household, the potentially broad geographic scope across which citizens derive benefits usually implies that the aggregate non-use value of the same ecosystem services in actually substantial.

The following two sections discuss a few studies conducted in Canada and US that measure non-use values to provide the context for this study.

3.3.1 Canadian studies measuring non-use values

There is a wide range of estimates of ecosystem non-use values in North America, with a more abundant literature in the U.S. relative to Canada. Table 3-2 identifies and summarizes key features of seven existing studies that have estimated non-use values for the restoration of various Canadian ecosystems using SP methods (P. C. Boxall et al., 2012; Dias & Belcher, 2015; D. P. Dupont, 2003b; J. Pattison et al., 2011; Rudd et al., 2016a; Sverrisson et al., 2008; Tanguay et al., 1995).

These studies valued several different ecosystem types: two studies addressed wetland improvement; two studies addressed marine mammals and riverine and coastal wetland species recovery; one study addressed boreal forests species (woodland caribou (*Rangifer tarandus caribou*)) improvement; and another one addressed water-based recreational activities improvement. All studies describe at least one restoration program, which consists of a certain number of attributes of an improved level compared to the status quo. These studies vary widely in the extent of the attributes selected to describe the improvement (restoration programs), which are selected based on how well they represent key ecosystem features at each study site, sensitivity to management actions, as well as other characteristics such as being quantifiable, easy to measure, and reliable. None of these studies has specifically addressed river delta restoration.

Four studies used DCE methods to elicit WTP; the remaining three used contingent valuation instead. The most common form of payment vehicle was an increase in taxes, followed by an increase in utility bills, one-time public conservation payment, increased wood product expenditure, or payment to a private foundation. All but one of the studies framed the payment as an annual cost incurred to households. Regarding the survey administration, most of them used web-based survey method, while the selected sample varied from residents in the immediate area of the affected ecosystem to provincial and national representative samples.

Table 3-2 Previous valuation studies capturing non-use values of ecosystems and their services in Canada

Category	(Dias & Belcher, 2015)	(Tanguay et al., 1995)	(P. C. Boxall et al., 2012)	(J. Pattison et al., 2011)	(Sverrisson et al., 2008)	(Dupont, 2003)	(Rudd et al., 2016)
Main ecosystem studied	Prairie wetlands, Saskatchewan	Northwestern region of Saskatchewan	St. Lawrence Estuary, Quebec	Prairie pothole region of Manitoba	Mixedwood Plains of southern Ontario	Hamilton Harbour, Ontario	Southern Ontario
Main conservation program	Wetland conservation/management scenarios differing in the levels of wetland attributes	Woodland caribou maintenance program	Six hypothetical programs on the improvement of status of a select group of marine mammals from their current levels (endangered, threatened, or special concern) to levels that include “not at risk” Expected levels in 50 years	Six wetland restoration scenarios for the southern region of Manitoba differing in the level of ecosystem goods and services provision (nutrient reduction, erosion control, flood control, carbon capture, biodiversity/number of breeding duck pairs)	Expansion of a protected area in the Mixedwood Plains of southern Ontario	Improvements in water-based recreational activities attendant upon efforts to rehabilitate Hamilton Harbour	Improvement of listing status for the little-known riverine and coastal wetland species under consideration

Main program impacts	Improvement of wetland attributes: - Riparian zone width (5 m width; 10 m width; 20 m width) - Wildlife population (no action; maintenance; conservation) Water quality (no change; moderate improvement; large improvement)	Saskatchewan program: caribou conservation program in Saskatchewan only Canada program: caribou conservation program at a national level	Affect the recovery of marine mammal species[7] and other related attributes	Baseline scenario/current situation: Further decrease of wetland acres from 1,000,102 to 949,184 acres in southern Manitoba Retention program: Retaining the wetlands that currently existed in southern Manitoba to the year 2020 Four additional programs involving restoration activities of various intensities ranging from	Baseline scenario: Coverage of protected areas in southern Ontario in 2006 Improvement programs differing in the increase of protected areas coverage compared to baseline scenario	Improvements to three water-based recreational activities (swimming, fishing, and boating) in Hamilton Harbour, Ontario Note: A split sample questionnaire design that divided respondents into three groups segregated by their use of the recreational activities: active,	Recovery[8] programs on the improvement of listing status for the little-known riverine and coastal wetland species under consideration, varying in their attributes (level of improvement varying from some improvement to large improvement compared to status quo). Status quo option assumed further

[7] Beluga whales species status (threatened, concern, recovery to special, recovery to not at risk);
Harbor seals species status (threatened, concern, recovery to special, recovery to not at risk);
Blue whales species status (threatened, concern, recovery to special, recovery to not at risk);
Size of marine protected area (MPA not present, small, large)
Shipping and whale watching industry regulations (current, minor increase, major increase)

[8] - Species survey attributes: SARA listing status of the riverine channel darter; SARA listing status of the coastal wetland pugnose shiner; Recovery time of the lake sturgeon
- Guild survey attributes: SARA listing status of riverine guild species; SARA listing status of coastal wetland species
- Ecosystem survey attributes: Status of the Water Quality Index in southern Ontario; Area (ha) of wetlands in the mixedhood plains ecozone

				12.5% to 100% of 1968 wetland areas by 2020.		potentially active, and passive users	declines in listing status for these species.
Valuation method	DCE	Contingent valuation	DCE	Contingent valuation	DCE	Contingent valuation	DCE[9]
Question format	Repeated choice scenarios (9 per respondent)	Open-ended WTP question and discrete choice WTP question	Repeated choice scenarios (6 per respondent)	Referendum	Repeated choice scenarios (8 per respondent)/Binary choice referendum format	Dichotomous choice	Repeated choice scenarios (8 per respondent)
Payment vehicle	One-time public conservation payment made by household (levels set at \$0.00, \$5.00, \$10.00, \$50.00, \$100.00, \$250.00, \$500.00)	Increased wood product expenditure; Payment to an independently run private foundation	Annual cost to the household in the form of increased federal income taxes; Increased prices for goods due to new restrictions on shipping (levels set at \$5, \$15, \$50, \$100 and \$350)	Annual cost to the household in the form of tax payment (levels set at \$25, \$50, \$100, \$200, \$350, \$500)	Annual cost to the household in the form of increased tax payment (levels set at \$20, \$60, \$175, \$ 325)	Household's water bill or rent (for tenants)[10]	Annual cost to the household in the form of tax payment (levels set at \$5, \$10, \$15, \$25, \$50, or \$100)
Survey mode	Web-based survey	Mail survey	Web-based survey	Web-based survey	Web-based survey	Mail survey	Web-based survey

[9] Note: Three DCE surveys conducted (guild survey; species survey; ecosystem survey)
[10] Note: The range of initial presented prices is \$10/year to \$40/year Canadian per household. The follow-up referendum question doubles these values for respondents who initially answer yes and halves these values for those who responded no.

Sample frame	Residents of the province of Saskatchewan	Saskatchewan region sample; Northwestern region sample	Canadian population	Residents of the province of Manitoba	Residents of the province of Ontario	Residents in Hamilton Harbour Watershed area	Residents in five geographical regions of Ontario
Sample size	250 completed surveys	2774 for the Saskatchewan sample; 1472 for the Northwestern region sample	2006 surveyed respondents	1,848 surveyed individuals	1,629 surveyed respondents	713 completed surveys	1,030 completed surveys
Survey year	2010	1992-93	2006	2008	2006	1995	2011
Value measure	WTP for wetland management attributes based on a one-time payment per household	Average 10-year annual household WTP of Saskatchewan residents to implement a woodland caribou	Average annual household WTP of Canadians to implement marine mammal species recovery programs, with expected levels to happen in 50 years	Average 5-year annual household WTP of Manitoba residents for wetland restoration programs in Manitoba	Average 5-year annual household WTP of Ontario residents to implement programs for expanding the protected area network	Median yearly household WTP of Hamilton Harbour residents for the three activities according to question order and user status	Average annual household WTP of Ontario residents to implement recovery programs for little-known aquatic species at risk in southern Ontario
Value estimate ($ per household per year)	- $ 79/household for a one level increase in riparian area - $ 70/household for a one level increase in wildlife population - $127/household for a one level increase in the water	- $132/household for the Canada program - $167/household for the	- $132/household/year for harbor seal recovery from threatened to special concern - $190/household/year for beluga recovery from threatened to special concern	- $501/household/year for retention at current level - $515/household/year for restoration to 80% of 1968 levels - $529/household/year for restoration to 30% of 1968 levels	-$213/household/year for 1% expansion of the protected area coverage - $277/household/year for 5% expansion of the protected area coverage	$20 - $31 /household/year for swimming activity based on question order (passive users only)	- $24/household/year per listing status increment of channel darter alone - $92/household/year per listing status increment of three

	quality (i.e. decrease in the frequency of boil water advisories) Note: (Original values reported in 2010 Canadian dollars; values presented here are converted to dollar values in 2021 base year)	Saskatchewan program Note: Above welfare measures are for the discrete choice WTP elicitation format Note: (Original values reported in 1991 Canadian dollars; values presented here are converted to dollar values in 2021 base year)	- $330/household/year for beluga & harbor seal recovery from threatened to special concern - $204/household/year for beluga recovery from threatened to not at risk - $357/household/year for beluga & harbour seal recovery from threatened to not at risk - $ 390/household/year for beluga & harbor seal recovery from threatened to not at risk and blue whale recovery from endangered to threatened Note: (Original values reported in 1991 Canadian dollars; values presented here are converted to dollar values in 2021 base year)	- $556/household/year for restoration to 89% of 1968 levels - $606/household/year for restoration to 100% of 1968 levels Note: (Original values reported in 1991 Canadian dollars; values presented here are converted to dollar values in 2021 base year)	- $390/household/year for 12% expansion of the protected area coverage Note: (Original values reported in 2007 Canadian dollars; values presented here are converted to dollar values in 2021 base year)	$10-17$/household/year for boating activity based on question order (passive users only) $ 13 - $15/household/year for swimming activity based on question order (passive users only) Note: (Original values reported in 1995 Canadian dollars; values presented here are converted to dollar values in 2021 base year)	little-known riverine species - $30/household/year per listing status increment of pugnose shiner alone - $94/household/year per listing status increment of five little-known coastal wetland species - $77/household/year for reduced lake sturgeon recovery time Note: (Original values reported in 2011 Canadian dollars; values presented here are converted to dollar values in 2021 base year)

As shown in Table 3-2, the resulting average annual household WTP estimates vary widely across the different studies, falling in the range from $10[11]/household/year to almost $606/household/year. This difference is expected considering the range of attributes (ecological indicators) being valued. However, welfare estimates derived from these studies highlight an important fact related to non-use values. Even if the dollar values put on individual non-use values might not be considered too significant, the aggregate monetary value associated with these non-use values is actually substantial. That is because of the potentially broad geographic scope across which citizens derive benefits from the improvement in quality (quantity) of the ecosystem being valued.

Most importantly, these studies reinforce the argument that the wide array of benefits that Canadians derive from ecosystems and their services go beyond the current or expected future contact with a certain aspect of the ecosystems. In other words, these studies support the importance of putting a monetary value and accounting for non-use values.

The results yielded by these studies, accentuate the importance of determining the full-extent of the affected population by a change of good or service, which proves to not be limited to direct users only. Such consideration is required for decision-making approaches such as cost-benefit analysis and is an indicator of the significance of gains and losses in social wellbeing.

In addition, insight is gained from these studies into the extensive process that each of them follows to derive welfare estimates. Choice of elicitation method, payment vehicle, attributes to describe the change in the ecosystem, to name a few, are decisions directly related to each site features and study objectives. Even though the process is guided by best practices and literature consultation, the researcher plays an important in making decisions and considering trade-offs. While challenges are an inevitable part of the research process, understanding common pitfalls pointed out from these studies helps limit those hindrances when estimating non-use values.

[11] All dollar values are converted to 2021 dollars using the consumer price index (CPI). Inflation calculator tool by Bank of Canada is used to present the inflation-adjusted dollar values from different years presented in section 3.3.1 of the thesis (Inflation Calculator - Bank of Canada, n.d.). Also, values are rounded up to the nearest whole number.

3.3.2 Illustrative US river restoration studies measuring non-use values

In this section, I discuss a few non-use valuation studies that have been conducted in the United States in the river restoration context including the case of Elwha River in Washington (Loomis, 1996), the Lower Snake River (Domanski, 2019), and Klamath River Basin (Graham et al., 2012). The purpose of this section is not to provide an overview of the US literature on non-use values, but rather support the argument made in this thesis regarding the existence and importance of quantifying non-use values for various ecosystems. River-restoration studies are chosen among other non-use studies because rivers can be considered fairly similar ecosystem types to river deltas.

In the case of Elwha river study, most of the near term benefits to respondents if dams were to be removed from the Elwha river are considered non-use values rather use values (Loomis, 1996). That is based on the argument that under such scenario, restoration of the river and return of the natural migration of the salmon were expected to occur within the first decade. Conversely, a few decades would be needed for a significant increase in harvestable fish return to support commercial and recreational fishing to happen, which would lead to use values. The first change in salmon population implies derivation of non-use values compared to use values linked with the harvestable fish return. Findings of the study showed that residents outside Washington State were willing to pay $124[12] per household per year to remove two dams on the Elwha River and restore the ecosystem (Loomis, 1996). In addition, the average WTP of Washington residents was $133 per household, resulting in positive net benefits for dam removal (Loomis, 2006). The estimated economic benefits of removing dams and restoring the Elwha River were significantly higher compared to the costs of approximately $ 250 million associated with the removal of two dams from the river.

Similarly, the study on Lower Snake River, which flows west to the Columbia river, the largest North American River showed that inclusion of non-use values of dam removals, which consisted of the indirect benefits of a restored river system and the potential saving of salmon from extinction, would justify the policy action (Domanski, 2019). The average household was willing to pay $43[13] per year to remove dams.

[12]Original values reported in 1994 US dollars. Values presented in section 3.3.2 converted to 2021 dollars using the consumer price index (CPI) (*Inflation Calculator | Find US Dollar's Value from 1913-2022*, n.d.). Also, values are rounded up to the nearest whole number.
[13] Original values reported in 2018 US dollars.

The estimates derived from the stated preference study on the total value households across the United Stated place on restoring the Klamath River Basin restoration, presented through alternative dam management proposals, were substantial as well (Graham et al., 2012). These values held for people regardless of whether they ever consume Klamath fish, visit the Klamath River Basin, or otherwise use the resources from the Klamath River Basin. The study estimated that the WTP[14] per household was $84[15] in the 12-county Klamath region and $147 in the rest of Oregon and California and the rest of the United States. The discounted present value of the 20-year stream of payments aggregated over households in each geographic regions in the United States ranged from $2035 to $3563 moving from the Klamath region to rest of the United States, and across the proposals, differing in the impacts on all the attributes used as indicators of the Colorado River restoration extent.

Again, similar to the Canadian studies, these studies illustrate the empirical importance of including non-use values in the analysis when calculating the benefits of ecosystem restoration, in addition to accounting for these values when damages occur. Substantial welfare estimates derived in each case support the fact that people do place a value on the restoration and conservation of riverine ecosystem services, even when they do not directly benefit from them, or expect to benefit anytime in the future.

[14] Annualized into an infinite stream of payments and assuming a discount rate of 4.125%.
[15] Original values reported in 2010 US dollars.

Chapter 4: METHODOLOGY

4.1 Introduction

This chapter describes the survey design and administration, the conceptual framework and econometric modelling technique used to estimate willingness to pay for restoration programs applied to the SRD.

4.2 Survey design and administration

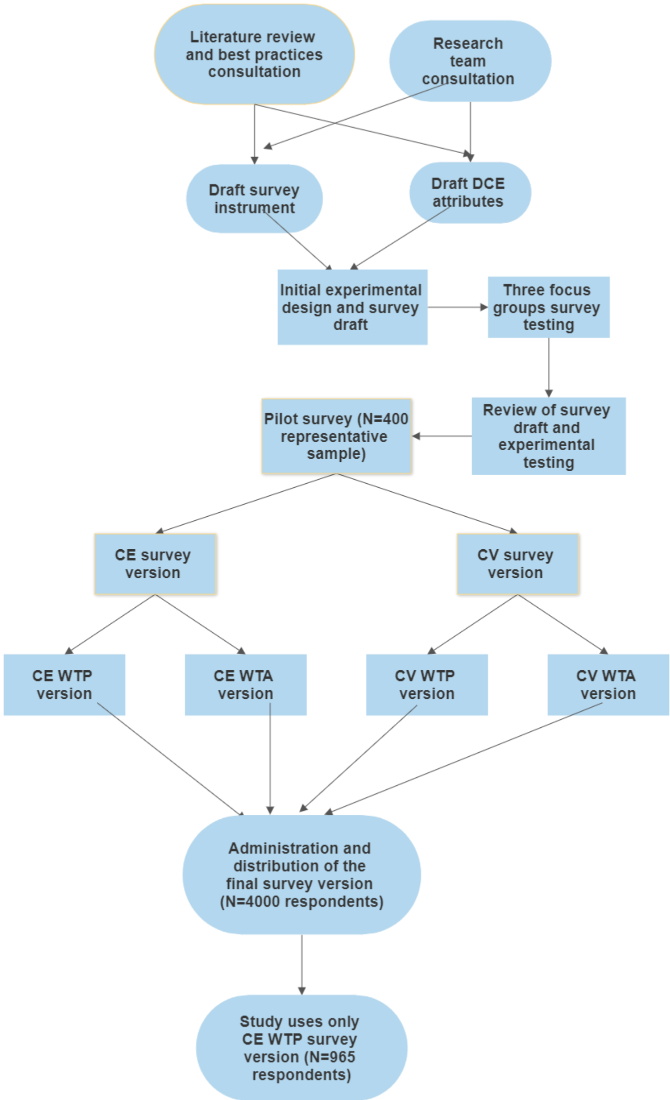

Figure 4-1 Survey development and implementation process

The methodology presented here (Figure 4 – 1) is in chronological order starting with a detailed description of the survey version used for the purpose of this study, the steps taken for implementation of the survey, the actual administration of the survey, and the considerations made in the design of the survey. I will go step by step through this figure section by section. The study received approval[16] from the University of Saskatchewan Behavioural Research Ethics Board. A copy of the certificate of approval is included in Appendix C.

4.2.1 Use of DCE approach and WTP concept for the purpose of this study

The final survey distributed online to the representative sample consisted of four different versions, which differ on the use of WTP versus WTA concepts to calculate marginal welfare measures and on the use of contingent valuation versus DCE elicitation SP technique (see Appendix A for the full survey).

For the purpose of this study, I have used only responses to the DCE and WTP framing to derive the welfare estimates. This decision is based on a thorough analysis of what makes the most sense in terms of how the research question should be framed from a decision-making context. According to guidelines developed by Johnston et al. (2017), DCE is considered more applicable when the change to be valued affects specific characteristics of the good or service. The restoration of SRD does make sense to be framed in terms of different ecological indicators that improve at varying levels. Obtaining marginal values of attributes and estimating the weights placed on each of them provides a richer characterization of respondents' preferences. Moreover, the SRD case gets more complicated primarily because of the uncertainty around what the future restoration scenario is. In this regard, it is of interest to present various potential restoration scenarios for policy-making rather than a single restoration program. Overall, for this study, DCE can provide more insight into the welfare estimates by allowing values for a variety of scenarios rather than a single estimate (in the case of contingent valuation).

However, this does not imply any superiority of this survey version over the remaining ones in all possible applications. No conclusions can be drawn from this study regarding the differences (if any) between the welfare estimates generated from each of the SP methods and if there is any disparity between a person's WTP and WTA. That requires

[16] Application ID: 2507; Approved on 11-Feb-2021.

further research that uses the responses generated through the other survey versions. Also, the incentive properties of DCE elicitation is a concern[17] that cannot be ignored when employing this technique.

The value of goods (services) may be measured in terms of WTP or willingness to accept (WTA). In the WTP context, individuals are asked the maximum they would pay to obtain an additional quantity or improvement in the quality of some service or group of services; in the WTA context, individuals are asked the minimum amount they would accept for a decreased quantity or degraded quality of some service. In other words, WTP provides a purchase price, relevant for valuing the proposed gain of the good, while WTA a selling price, relevant for valuing a proposed resource damage. This study considers an environmental improvement or gain of the good. Therefore considering all the above, WTP is considered conceptually[18] appropriate.

4.2.2 Structure of Survey

The survey comprised six distinct sections, described in detail below. Respondents were not allowed to return and edit previous answers as they moved through the survey, because the ordering of questions is viewed as critical in obtaining valid and reliable results.

Section 1 provides a short introduction designed to present some general information about Saskatchewan River Delta, its status and how it is negatively impacted by upstream activities. The section also asks some preliminary questions to assess respondents' familiarity with the Saskatchewan River Delta and their concern about the delta ecosystem in general.

Section 2[19] provides information on various conservation actions to improve the condition of the delta. It also explains that the actions come with many costs, including

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[17] According to Carson and Groves (2007), incentive compatibility of stated preference questions for public goods requires, among other conditions, that respondents face a single dichotomous choice value question, a condition which is violated by DCE.

[18] If WTP and WTA were the same for most individuals and services, the choice between them would not be a problem for economic valuation; but as Hanemman (1991) has demonstrated, a substantial difference between the two is possible for services provided by non-marketed resources. Therefore, the decision as to which measure to use may have important policy implications.

[19] The description refers to the WTP DCE survey version which is used in this study. The other WTP survey version uses CV elicitation method and is outside the scope of this study. The same applies to two other survey versions both using WTA concept to calculate marginal welfare measures but differ in the employment of CV and DCE elicitation techniques. Consistent with the WTA concept, section 2 for WTA survey versions provides information on various development activities in the Saskatchewan River Basin that are expected to degrade the natural resource conditions in the delta unless mitigation tools are undertaken to adverse the negative impacts. If future development occurs,

monetary expenses in the form of a fixed annual federal tax increase expected to last for a period of 20 years. This tax is the monetary attribute presented in the choice tasks.

Section 3 presents the detailed description of the four environmental outcomes of interest to the survey, how they change at different levels in the range from 0 – 100, and what the variation implies in terms of the improvement in their abundance or provision level across the status quo and other alternative scenarios in the choice sets. Visual aids are used in this part of the survey.

Section 4 is the heart of the study that includes the valuation questions. Respondents are asked six choice set questions, each consisting of three alternatives, described below in Sections 4.2.5 – 4.2.6 of the thesis.

Section 5 includes a series of follow up questions which are viewed to serve multiple purposes (Johnston et al., 2017; Pattison, 2009; Pennington et al., 2017) such as:

(a) evaluating elicitation questions validity;

(b) identifying cases of the rejection of the scenarios because of respondents refusal to indicate their WTP for SRD restoration;

(c) identifying cases of votes for a proposed SRD improvement solely because of respondents' moral satisfaction from agreeing with questions on such causes;

(d) understanding respondents opinions and behaviours on a broader scope of environmental issues.

Section 6 elicits demographic and individual information used to enable an examination of how welfare estimates are affected by the social and economic characteristics of the survey respondents. The data included information on the province of residence, age, income, level of education, occupational status, and other characteristics.

4.2.3 Survey pretesting: Focus groups and pilot testing

Survey pretesting included focus groups and a pilot test. These processes were conducted to check survey understanding and update experimental design before distributing the final version to the representative sample. Pretesting is a central component of content validity (Carson, 2012; Johnston et al., 2017) which helps detect and address mitigating biases, such as sequencing, hypothetical biases, and other potential forms of strategic behaviour. Effective

Canadian household will be compensated by the government through a uniform refundable tax credit for 20 years, which constitutes the monetary attribute in the choice alternatives.

feedback was received during this phase, based on which important components of the survey should be redesigned to improve its overall flow.

Three online focus groups consisting of 4 to 6 individuals across Canada were conducted during the period, May 03 – May 06, 2021. Initially, participants went through the survey on their own, as they would do if the final survey was distributed to them online. This step allowed the collection of preliminary data based on their individual responses to the survey. Then, I moved to a group discussion about various aspects around the survey structure, the research topic, and the study site.

Most of the participants mentioned that they had never heard of the Saskatchewan River Delta before the focus group. However, they stated that, regardless of the low familiarity with the good being valued, information and the language presented in the survey helped them get the necessary knowledge to make an informed decision in the end. Presentation of future actions at the beginning of the survey was viewed as positive in terms of the credibility of the survey. Also, participants found it interesting that the study is asking for Canadians opinions on a national level and the SRD ecological problems was not limited to only people who are directly impacted by them. They did like the fact that the tax was outlined at the beginning of the survey and that it was at the federal level. According to their feedback, the survey made them sit back and think if they were going to pay each of the tax amounts presented, which means that they perceived the survey responses to be consequential.

After the survey design was updated based on the feedback received from the focus groups regarding the adequacy of the amount and level of information required to answer valuation questions, I moved to the pilot-testing phase. A pilot study was distributed online to a sample of 400 random participants across Canada, in July 2021. Execution of this step benefited the development of the final DCE survey in the following ways:

(a) helping to detect potential problems, primarily logistical ones, with the distribution of the survey before collecting the main sample;

(b) generating preliminary data to run an initial econometric analysis; and

(c) defining the prior coefficients which were then used to update the experimental design for the final survey (Mariel, Hoyos, Meyerhoff, Czajkowski, Dekker, Glenk, Jacobsen, Liebe, et al., 2021) .

The last one is particularly important given that the main advantage of an efficient DCE lies in the fact that prior knowledge in the form of "prior coefficients" can be included (Traets et al., 2020). In order to ensure the robustness of the model, at least, priors, which are best guesses for the unknown parameters to be estimated, should be chosen such that they do not deviate much from the true parameter values in terms of the expected signs and parameters. Pilot testing procedure is an effective strategy in this regard.

4.2.4 Main survey administration

The final data was collected in August 2021 via an internet panel from approximately 4,000 individuals, representative of the general Canadian population. The version used in this study makes use of the total information collected from the subsample of 965 individuals that completed one of four versions of the survey. The other three subsamples are outside the scope of this study. The survey was distributed and administered by the Canadian Hub for Applied and Social Research, University of Saskatchewan (CHASR). To ensure coverage and representation of the Canadian population residing in all the provinces, non-random quota-sampling technique was applied when inviting the respondents from the Asking Canadians' online access panel, the company contracted by CHSAR. The quota-based survey sampling ensured that the sample was representative in terms of province of residence, age, and gender.

Online administration of the survey was chosen as the survey mode for four reasons (Champ et al., 2003; Mariel et al., 2021). First, with a web-based survey it is easier to reach a large number of demographically different participants across Canada, to ensure a representative sample, which in turn affects the extrapolation of the sample results to the entire population, compared to other survey methods (i.e. mail survey, telephone survey, face-to-face survey). Second, this method saves time in both the quick delivery of the survey to the participants, regardless the geographic distances, as well as in the randomization of responses, employed in this survey, and data collection step. Another important reason has to do with the fact the web-based method captures the time that respondents take to answer the choice tasks and other parts of the survey. This information is very useful when analysing if respondents have taken enough time to answer questions carefully for validity purpose. Also, this method does not allow respondents to move ahead or go back and modify their responses. This feature is essential given that respondents must consider the choice sets as independent and thus answer the questions without comparing them strategically, which would affect the efficiency of DCE.

There are also disadvantages of the online survey mode for data collection that should be considered when deciding to implement this methodology. For example, aside from the demographic variables, relatively little may be known about the characteristics of participants completing the survey. This turns into an important issue especially when the data is selfreported, as there is no guarantee that participants provide accurate demographic and characteristics information. Additionally, online survey response rate is potentially influenced by interests of participants, with participants more likely to complete a survey if they are interested in the topic. This can cause a self-selection bias, which, in turn, limits the ability to extrapolate the sample results to population. Bearing in mind that, the purpose of this study is to estimate non-use values of Canadians to restore SRD, it is of interest to investigate if only respondents who are familiar with the delta have completed the survey. Based on their responses, 65% of respondents said they had never heard of the delta before and only 10% had visited the delta before, indicating that self-selection bias is not a concerning issue encountered in our web-based survey.

4.2.5 Sample representativeness

Whether or not the survey sample accurately portrays the target population being studied, in this case the general Canadian population, directly affects the application of derived welfare measures to the population. A comparison between the sociodemographic characteristics of the sample with information from Statistics Canada Census for the year of 2016 (Statistics Canada, 2016) is provided in Table 4-1.

Respondents' characteristics and the census data in terms of province of residence, age range, and gender data were fairly similar, which is expected because of the quota-sampling applied in the selection of the sample. Percentages of respondents residing in Canadian provinces reflects how the Canadian population is unequally distributed across the country.

Because the study focuses on capturing non-use values, it is of interest to investigate the percentage of respondents residing in the Prairie Provinces of Saskatchewan, Alberta, and Manitoba. Only 24% (N=231) of respondents reported residing in the Prairie Provinces compared to 20% in Census. Gender was approximately equal with a similar age range distribution compared to that reported by the Canadian population census. Age range distribution for the sample participants was similar to the Census data, with the exception of the groups 25 – 34 years old and 64 – 74 years old, for which the percentages are slightly different. It should be noted that while only people 18 years old and above were surveyed for this study, Census 2016 reports the information on the total population.

Table 4-1 Comparison of sample characteristics with Canadian census data

Characteristics		**Sample (N = 965)**	**Census Canada for 2016**[a]
Province	Alberta	87 (9%)	4,442,879 (13%)
	British Columbia	124 (13%)	5,214,805 (14%)
	Manitoba	71 (7%)	1,383,765 (4%)
	New Brunswick	13 (1%)	789,225 (2%)
	Newfoundland and Labrador	7 (0.7%)	520,553 (1%)
	Northwest Territories	1 (0.1%)	45,504 (0.1%)
	Nova Scotia	24 (2%)	992,055 (3%)
	Nunavut	1 (0.1%)	39,403 (0.1%)
	Ontario	359 (37%)	14,826,276 (39%)
	Prince Edward Island	4 (0.4%)	164,318 (0.4%)
	Quebec	199 (21%)	8,604,495 (22%)
	Saskatchewan	73 (8%)	1,179,844 (3%)
	Yukon	2 (0.2%)	42,986 (0.1%)
Age range[b]	18 – 24 years old	56 (6%)	2,452,701 (8%)
	25 – 34 years old	198 (21%)	5,337,898 (18%)
	35-44 years old	158 (16%)	5,333,294 (18%)
	45-54 years old	170 (18%)	4,814,807 (16%)
	55-64 years old	143 (15%)	5,307,066 (17%)
	65-74 years old	182 (19%)	4,087,529 (13%)
	75+ years old	58 (6%)	2,994,264 (10%)
Gender	Man	459 (48%)	19,007,832 (50%)
	Woman	494 (51%)	19,238,276 (50%)
	Gender non-binary/third gender/other	12 (1%)	NA
Yearly pre-tax income[c]	$0-$9,999	13 (1%)	3,877,620 (14%)
	$10000-$29999	76 (8%)	8,488,220 (31%)
	$30000-$49999	105 (11%)	6,033,220 (22%)
	$50000-$69999	123 (13%)	3,834,845 (14%)
	$70000-$89999	142 (15%)	2,238,735 (8%)
	$90000-$124999	139 (14%)	749,290[d] (1%)
	$125000-$149999	90 (9%)	1,493,570[e] (5%)
	$150000-$199999	84 (8%)	773,025[f] (3%)
	Over $200,000	56 (5%)	
Education [g]	Less than high school	15 (2%)	5,239,575 (18%)
	High school graduate	108 (11%)	7,576,400 (27%)
	Vocational/Trade/Technical School	138 (14%)	2,800,265 (10%)
	Some University/College	202 (21%)	6,367,160 (22%)
	Bachelor's degree	318 (33%)	4,443,835 (16%)
	Advanced degree	184 (19%)	2,024,850 (7%)
Employment status[h]	Employed full time	498 (52%)	9,626,010[20] (34%)
	Employed part time	89 (9%)	9,735,000[21] (34%)
	Unemployed	36 (4%)	9,282,005[22] (32%)
	Student	43 (3%)	
	Retired	276 (29%)	

[20] Includes persons aged 15 years and over who worked full year (49 weeks and over) and mostly full time (30 hours or more per week) in 2015.
[21] Includes persons aged 15 years and over who worked full year mostly part time or part year mostly full time or part year mostly part time in 2015. Part year is less than 49 weeks and part time is less than 30 hours per week.
[22] Includes persons aged 15 years and over who never worked, persons who worked prior to 2015 and persons who worked in 2016, but not in 2015.

	Full-time homemaker	23 (2%)

[a] N = 35, 151,730 from Census 2016 refers to the whole population (0 to 14 years – 85 and over).
[b] The total number from Census Canada used to calculate percentages by age range is 30,327559 and it refers to the portion of population that falls into the age range 18 years old – above.
[c] Income level reported by the Census Canada is yearly total income (before taxes) in constant (2015) CAD dollars for the population aged 15 years and over in private households (N=28,642,980). Percentage with total income 27,488,530 (96%).
[d] This value is for the income group $90,000 to $99,999.
[e] This value is for the income group $100,000-$149,999.
[f] This value is for the income group $150,000 and over.
[g] The total number from Census Canada used to calculate percentages by education level is 28,643,015. This number refers to the population aged 15 years and over in private household.
[h] The total number from Census Canada used to calculate percentages by employment status is 28,643,015 and it refers to the total population aged 15 years and over by Labour force status.

Source: (Statistics Canada, 2016)

Examining the sample and Census data for respondent characteristics that were not subject to quota-based sampling yields some differences. How the reported percentages compare to each other changes from one income range to another, but they generally differ between the sample and the 2016 census. The percentage of respondents that reported to be either full or part-time employed at the time of survey completion was higher compared to Canada's 2016 Census, while most respondents stated that they had at least completed some university/college education. Overall, the sample is representative of the Canadian population in terms of province of residence, age range, and gender.

4.2.6 Selection of Attributes and Levels

As an attribute-based survey, the validity and reliability of the DCE results depends on the appropriate specification of the attributes and their levels. Attribute development followed a rigorous and systematic process, to ensure the identification of credible attributes that are measurable[23], interpretable[24], applicable[25] and comprehensive[26] (Johnston et al., 2017; Schultz et al., 2012). The information is gathered through:

[23] Have a clearly stated relationship to ecological data or model results.
[24] Different values of the metric have consistent meanings to survey respondents, subject experts, and resource managers.
[25] Understandable by respondents and link to management scenarios.
[26] The degree to which all direct and indirect ecosystem impacts are described by the metric(s) and understood by the respondent.

(i) discussions with the research team members, with an expertise in the river deltas as complex social-ecological systems and human dimensions of water security;

(ii) literature review of previous studies, although limited in number, that seek to evaluate the non-use values associated with the restoration of a river delta;

(iii)literature review of studies focused on the ecology aspects of the SRD and related information *(e.g. the relationship between different ecological indicators and the SRD health, historical trends on how the ecological indicator have been impacted by upstream human interventions and how reversible those negative impacts are if restoration actions are put into place)*;

(iv)structured conversations with three focus groups to analyse the credibility and clarity of the initially selected attributes and their levels and test if changes needed to be made for the final selection, as discussed in Section 4.2.6.

Additionally, the perception of attribute bundles and how they are dependent on each other (Champ et al., 2003) is considered in the selection of DCE as the approach to be used. This aspect is controlled during the experimental design of the choice sets and the use of the Random Utility model, which are constructed such that no correlation between attributes is allowed. Moreover, lake sturgeon population, waterfowl population, muskrat abundance, and habitat in healthy ecological condition can reasonably be considered independent attributes from an ecological perspective. Although no exact information can be provided in this regard, it is reasonable to say that different restoration programs will affect the attributes differently and not lead to the same exact change. The exact impact will most likely depend on the target of the restoration program and measures associated with it.

The attributes selected for the choice sets are lake sturgeon, waterfowl population, muskrat abundance and habitat in healthy ecological condition.

- **Lake Sturgeon *(Acipenser fulvescens)***

Lake sturgeon are considered a sensitive indicator of overall aquatic health of the delta ecosystem. One of the largest, longest-lived, freshwater fish species in Canada and with a special significance to Indigenous people, lake sturgeon are currently listed as endangered by the Committee on the Status of Endangered Wildlife in Canada. Population levels in the delta have been fragmented due to hydroelectric development upstream and past harvest. Current levels of lake sturgeon population are estimated to be 10% of historical abundance. Lake sturgeon exhibit a number of characteristics, which make it a sensitive indicator of overall aquatic health of the delta ecosystem; they mature at a relatively late age and spawning takes place over a large time extent once every three to five years. Because they migrate up to

100km between their breeding and non-breeding grounds, lake sturgeon are threatened by habitat fragmentation. The conservation target for the delta population is 10,000 adult fish to allow for subsistence harvest by the local community.

In the survey choice sets, levels of lake sturgeon refer to the total estimated size of its population compared to the conservation target of 10,000 adult fish. The score varies from 0% to 100,% where 100 means that the population meets the conservation target and 0 means no fish. Without management changes, the score in the delta will be 35.

- **Waterfowl population *(Anseriformes)***

The Saskatchewan River Delta has historically provided habitat for large numbers of waterfowl giving this ecosystem the status of being internationally recognized as an Important Bird Area. The area is an important migratory stopover location and contributes significantly to waterfowl populations in North America. Hundreds of thousands of ducks nest in the delta each year but these numbers have decreased from around 800,000 during the late 1960s to 200,000 in the 2010s.

In the choice sets, waterfowl population levels refer to the estimated size of waterfowl populations compared to historical levels of 800,000 breeding ducks possible. The score varies from 0 to 100, where 100 that populations are the largest natural size possible and 0 means no birds. Without management changes, the score in the delta will be 25.

- **Muskrat abundance *(Ondatra zibethicus)***

Muskrats are particularly sensitive to changing water levels and upstream river flow alterations making them an important indicator of overall wetland ecosystem health and ecological deterioration. As a consequence, the population levels of muskrat population have declined in the delta, with the current muskrat harvest levels being 99% below 1960s levels. That also affects the local community because muskrats are a wetland-dependant aquatic fur-beaver that has been harvested for food and their furs.

In the choice sets, muskrat abundance refers to the estimated abundance of muskrats compared to historical levels. The score varies from 0 to 100, where 100 means that populations are the largest natural size possible (20 muskrat found per hectare) and 0 means no muskrat. Without management changes, the score in the delta will be 5.

- **Habitat in healthy ecological condition**

Ecological condition is an outcome that measures the quantity of the delta in healthy ecological condition, and is measured using local Indigenous knowledge and recognized standards. The abundance and diversity of wildlife in the delta depends on the ecological health of the streams, lakes, wetlands, and uplands. Habitat degradation and loss has occurred in the delta due to: less water and sediments entering the delta; permanent flooding of wetlands for hydropower reservoirs (100,000 hectares); conversion of wetlands to agriculture (50,000 hectares); and invasive species that out-compete native species for water and nutrients such as an aggressive plant named Phragmites (European Common Reed).

The score varies from 0 to 100 showing the quantity of habitat in the delta in healthy ecological condition, where 100 means that all 900,000 hectares of the delta wetlands and lakes is in healthy ecological condition. Without management changes, the score in the delta will be 45.

All the above descriptive information on the ecological attributes and what makes them important indicators of overall SRD ecosystem health is presented to respondents prior to valuation questions. The changes in the levels of selected attributes are presented for the next 20 years because this timeframe is considered realistic in terms of the period of time required for the primary conservation activities to take place and changes in the provision levels of the attributes to happen.

- **Annual cost to households for 20 years**

This study uses an annual cost to household for 20 years, in the form of a federal income tax, as a monetary attribute. This cost associated with the hypothetical policy restoration alternatives is included as an attribute along with the ecological attributes. This makes it possible to convert the parameter estimates generated from the probabilistic choice models into willingness to pay estimates for changes in attribute levels (Adamowicz et al., 1998).

Choice of payment vehicle relies heavily on the institutional context of the country because it is crucial for it to be considered realistic, relevant and consequential by the respondent (Mariel et al., 2021). Respondents' belief in payment consequentiality in a SP survey can influence the estimation of WTP and the probability of them revealing truthful preferences (Johnston et al., 2017; Liu et al., 2020). Annual income taxes are viewed as compulsory payment made by Canadians to the government which partially uses the collected budget to fund a series of environmental programs and invest toward healthy environment programs (Environmental Funding Programs - Government of Canada). Also, the feature of the payment must be consistent with the mechanisms described to bring about the change to be valued (Johnston et al., 2017). The survey draws responses from a national survey so a national payment vehicle is needed.

This guideline applied in our study indicates that it makes sense to frame the payment as a yearly payment in the form of increased taxes that would have to be paid over the next

20 years from the start date of the restoration program, matching the length of conservation activities. Additionally, longer payment periods mean that budget constraints, particularly for lower income households, are less binding. Focus groups and pre-testing were used to identify any possible issues associated with the attributes or payment consequentiality, among other purposes.

In DCE, just as important as the attribute selection, which tell what parts of the alternative choices available to the respondent differ, is the choice of levels, which show the actual values for each attribute presented to the respondent. Getting the attributes and their levels "right" such that they properly describe the good or service of interest is important for the statistical analysis and interpretation of the data because it mitigates the possibility of having biased estimated coefficients.

This study uses both relative change and absolute change to describe variations in attribute levels across alternatives for each choice set questions. Table 4-1 shows the levels of the ecological attributes and monetary attributes and how they vary across the restoration scenarios compared to the status quo (baseline alternative).

Table 4-2 Attributes and Levels used in the DCE survey

Attributes	Lake Sturgeon	Waterfowl Population	Muskrat Abundance	Habitat in healthy ecological condition	Annual cost to your household for 20 years
Levels	10% 1,000 of 10,000 adult fish conservation target	15% 120,000 of 800,000 breeding ducks possible	**5% 1 muskrat found per hectare out of 20 possible**	30% 270,000 of 900,000 hectares	$0 Increase in annual taxes for 20 years
	35% 3,500 of 10,000 fish conservation target	**25% 200,000 of 800,000 breeding ducks possible**	20% 4 muskrats found per hectare out of 20 possible	**45% 405,000 of 900,000 hectares**	$15 Increase in annual taxes for 20 years
	60% 6,000 of 10,000 fish conservation target	50% 400,000 of 800,000 breeding ducks possible	40% 8 muskrats found per hectare out of 20 possible	60% 540,000 of 900,000 hectares	$55 Increase in annual taxes for 20 years
	100% 10,000 of 10,000 fish conservation target	75% 600,000 of 800,000 breeding ducks possible	70% 14 muskrats found per hectare out of 20 possible	85% 765,000 of 900,000 hectares	$170 Increase in annual taxes for 20 years

Attributes	Lake Sturgeon	Waterfowl Population	Muskrat Abundance	Habitat in healthy ecological condition	Annual cost to your household for 20 years
					$325 Increase in annual taxes for 20 years

Note: Levels in bold indicate the values of attributes for the Status Quo alternative

4.2.7 Choice set construction

Once attributes and levels have been determined, the next step is choosing the number of alternatives in each choice set, the number of choice sets per person, and constructing the feasible sets of attribute-level efficient combinations using experimental design.

The choice sets offered respondents a choice between a No Action (Status Quo) plan and two alternatives that differ in terms of the level of attributes. The Status Quo Alternative is interpreted and presented to the respondents as what outcomes are expected to happen over the next 20 years if no new delta conservation project occurs, and would not increase the costs to respondents' household. These levels were the same for all respondents. Alternatives A and B show the expected outcomes over the next 20 years under two of the many potential future scenarios that do more and cost more to conserve the delta. An example choice set is displayed in Figure 4 – 2.

	Results in 20 years		
	Status Quo	Alternative A	Alternative B
Lake Sturgeon	**30%** 3,000 of 10,000 fish conservation target	**15%** 1,500 of 10,000 fish conservation target	**100%** 10,000 of 10,000 fish conservation target
Waterfowl population	**25%** 200,000 of 800,000 breeding ducks possible	**50%** 400,000 of 800,000 breeding ducks possible	**75%** 600,000 of 800,000 breeding ducks possible
Muskrat abundance	**5%** 1 muskrat found per hectare out of 20 possible	**30%** 6 muskrats found per hectare out of 20 possible	**60%** 12 muskrats found per hectare out of 20 possible
Habitat in healthy ecological condition	**45%** 405,000 of 900,000 hectares	**60%** 540,000 of 900,000 hectares	**75%** 675,000 of 900,000 hectares
Annual cost to your household for 20 years	**$0** Increase in annual taxes for 20 years	**$15** Increase in annual taxes for 20 years	**$325** Increase in annual taxes for 20 years
I would vote for…	☐ Status Quo	☐ Alternative A	☐ Alternative B

Figure 4-2 Example of a choice set consisting of the status quo alternative and the two restoration alternatives

The number of choice sets presented to respondents was selected in accordance with psychologists' acknowledgement that processing up to six pieces of information is not difficult (Miller, 1994). The number of choice sets presented to each respondent is important since the level of task complexity might predispose respondents to use simplification strategies *(e.g. choosing a scenario based on one attribute only (Tversky & Kahneman, 1974) or the use of other simplified heuristics (Iyengar & Kamenica, 2010))* and thus produce irrational responses and biased results. It should be noted that, stated preference studies investigating the relationship between the numbers of choice sets presented to respondents and fatigue have not found strong evidence that would indicate a maximum number of choices that they would be able to respond to before getting tired (Campbell et al., 2015; Czajkowski et al., 2014; Hess et al., 2011; Meyerhoff & Glenk, 2015).

I used a Bayesian D-efficient design for the combination of the choice sets to be constructed such that the standard errors of parameter estimates are minimized. I used NGene® software to generate sixty choice sets that were then combined in ten blocks of six choice sets each. Further details on the theory of D-efficient design and alternative design measures is given in the NGene® manual (Ngene 1.2 User Manual & Reference Guide , 2018) as well as illustrated in the van den Broek-Altenburg & Atherly(2020) study. Each respondent was randomly assigned to one of the ten blocks.

Although it is recommended to use a high number of choice tasks in order to have a sufficient number of choices available for respondents it is quite impossible to present all the possible combinations of attributes and levels (Champ et al., 2003). Experimental design procedure helped identify and select subsets of those combinations such that the alternatives presented to respondents provide sufficient variation over the attribute levels to allow the identification of preference parameters associated with the attributes (Champ et al., 2003). Different design generation strategies such as orthogonal design, optimal orthogonal in the differences design, and efficient design have been formulated to ensure the choice task design presents respondents with the trade-offs that provide the researcher the best possible information about preferences in the sample of interest.

Additionally, focus groups and pre-testing (which are described in section 4.2.3) are considered valuable tools in this context because they can be used to test if the intended number of choice tasks are manageable for the average respondent (Mariel et al., 2021). The final number of choice tasks of this study is determined based on all the above criteria and process.

4.2.8 Explanatory variables

Coding of the data was done according to the attribute levels, entered in a cardinal linear form (i.e., increase or improvement of their levels compared to the status quo). The explanatory variables along with their description and how they are coded are reported in the following table. The dependent variable is the utility respondents derive from selecting one of the presented alternatives (Status Quo, Alternative A or B).

Table 4-3 Description of the explanatory variables used in the econometric analysis

Explanatory Variables	**Definitions**
Attribute variables	
Status Quo	Alternative specific constant for the status quo captures the variation in choices that is not explained by the attributes.
Lake sturgeon	Total estimated size of its population compared to the conservation target of 10,000 adult fish. WTP is measured for a 1% increase in the total estimated size of lake sturgeon population.
Waterfowl population	Estimated size of waterfowl populations compared to historical levels of 800,000 breeding ducks possible. WTP is measured for a 1% increase in the total estimated size of waterfowl population.
Muskrat abundance	Estimated abundance of muskrats compared to historical levels. WTP is measured for a 1% increase in the estimated abundance of muskrats.
Habitat in healthy ecological condition	Quantity of habitat in the delta in healthy ecological condition. WTP is measured for a 1% increase in the estimated area of habitat in healthy ecological condition.
Annual household cost for 20 years	The annual tax each household would have to pay for 20 years if one of the alternatives representing improvement policy options would actually take place.
Individual specific characteristics	
People age 45 and older[27] (N=553 or 57%)	Age range for 45 and older (Dummy variable for older group 45 and older = 1, otherwise *(age 18- 44)* = 0)
Male (N=459 or 48%)	Dummy variable for sex (Male = 1; Female = 0)
Prairie Province (N=231 or 24%)	Dummy variable for province (If Alberta, Saskatchewan, or Manitoba = 1, Rest of Canadian provinces and three territories = 0)
High Education (N=502 or 52%)	Respondents hold at least a Bachelor's degree, coded 1 for Bachelor's degree or Advanced degree, otherwise 0
High Income (N=369 or 38%)	Income from all sources before tax, coded 1 for over 90,000 and 0 for a levels lower that threshold *(0 - $89,999)*

[27] Research indicates that people grow less supportive of spending money to protect the natural environment as they age (Johnson & Schwadel, 2018). It is of interest to investigate if the same holds true in this study. Above all, insight can be gained into the demographic to be targeted by policy actions and environment restoration organizations.

Explanatory Variables	Definitions
Employed (N=587 or 61%)	Employment status of respondents at the time of survey completion, coded 1 for employed either full time or part time, 0 otherwise
Note: Values in parentheses for individual specific characteristics represent the summary statistics for these variables based on how they are coded.	

4.2.9 Survey design considerations and issues

There are quite a few design considerations and issues in stated preference surveys that, unless properly implemented and addressed, can seriously impact results and credibility of the study. This section describes these issues and explains how they were addressed in this study.

4.2.9.1 Reliability and validity

Survey design is important for the reliability and validity of the DCE study. Reliability refers to the consistency of the research instrument and is a statistical measure of the reproducibility of the survey data. In other words, reliability considers the extent to which the survey questions consistently elicit the same results over repeated measures (Crocker & Algina, 1986).

On the other hand, validity represents the extent to which a survey instrument measures what it claims to measure (Gregory, 2004). Bishop and Boyle (2018) outline three different aspects of validity, referring to as “the three Cs”: content validity, construct validity and criterion validity. All these three aspects of validity are important for assessing the validity of welfare estimates obtained from the DCE survey. Content validity concerns the extent to which the chosen valuation method, as well as all aspects of its practical implementation, is appropriate and conducive for obtaining a measure of the true value (i.e does the survey design follow best practice guidelines). Construct validity relies on economic theory, researcher’s experience and past research to address the issue of how well the construct (what is it you want to measure or operationalize) that is purported to be measured actually has been measured (i.e. are people less likely to vote for a program with higher costs, thus getting responses that align with theory). Criterion validity refers to the extent to which preferences elicited by the DCE method are related to another measure called criterion which is considered “true” or at least closer to the theoretical construct of the survey, such data from real or simulated markets (Bateman et al., 2002). It is important to highlight that finding this criterion is almost impossible for most non-use studies exactly because of the failure of markets to capture non-use values.

It is recommended that the three Cs of validity should be considered from initial conceptualisation of the environmental DCE survey through to data collection and analysis. The components of the survey used in this study have been designed and developed following as many as possible of the best-practice recommendations for SP studies (Johnston et al., 2017) that concern questionnaire development, scenario descriptions, survey information, attributes selected, survey mode, survey sampling of respondents, payment vehicle, strategies used to address hypothetical bias and strategic bias, etc. These guidelines support our goal of inducing respondents to reveal their true preferences through the choices they make in the survey evaluation questions and valid welfare estimates. This in turn will ensure as far as possible that the estimated values from the selected sample will reflect Canadian population's actual values for the improvement of the ecological condition of the delta. However, it needs to be highlighted that the main motivation for conducting a DCE survey to begin with is the lack of true values and failure of market data to capture the non-use values associated with certain ecosystem goods and services, such as the case of Saskatchewan River Delta. Therefore, ultimately, end users of the study will make their own assessment based on the information provided about all the steps from the questionnaire development to background for the welfare estimates.

4.2.9.2 Hypothetical and strategic bias

It is crucial that respondents view their responses to the survey as potentially influencing policy decision-maker's actions and that they care about the outcomes of these actions, for the responses to be interpretable using mechanism design theory concerning incentive structures. If the survey fulfils these two criteria, it is considered to be incentive compatible (Carson & Groves, 2007). The concept of incentive compatibility is linked to the issue of hypothetical and strategic bias, which is always a potential risk when conducting stated preference surveys, because of the hypothetical scenarios and absence of real market transactions. Hypothetical bias is a distortion that arises when respondents report unrealistic behaviours different to that of their real behaviour (Buckell et al., 2020). When respondents purposely misrepresent their preferences by inflating the economic value they place upon an outcome beyond the value they would be willing to pay if they were actually required to pay for it, in order to influence the conclusion in a favour of a certain desired policy, it is considered that they exhibit strategic bias (Meginnis, 2018). The two main effects are: an abnormal number of non-responses or when the questions are answered, the responses do not reflect the real preference of the individual.

Different incentives are used to induce the revelation of respondents' true preferences and mitigate potential bias (Dillman et al., 2014; Johnston et al., 2017). For instance, the survey includes information to present the importance of the research and present the research as part of a recognized institution (University of Saskatchewan). Additionally, information on the funding source of the survey and the provider, confidentiality, storage of data, etc., as well as contact forms to address questions or concerns were provided in the beginning of the survey.

In addition to above, presenting the vehicle payment in such a way that is perceived as consequential and can credibly impose costs on the entire sampled population so that free-riding is not possible is another way to deal with strategic bias (Arrow et al., 1993). This survey uses a credible payment mechanism - an increase in annual household taxes.

Also, a reminder of income constraints is included in the survey to remind respondents of the consequential trade-offs they are making in valuation scenarios, so to influence them into a more realistic response. In our survey, respondents are reminded prior to valuation questions that choosing to pay for environmental improvement of the delta means they would have less money available to buy other things and emphasizing how important it is for respondents to make the choice between the three alternatives in each choice set like they would if they were actually facing the exact choices in reality.

Furthermore, because each respondent is assigned six different random choice sets, they are asked to treat each of them as a separate choice. This information is provided with the intent of reducing the possibility of respondents inferring how responses over multiple choice sets would determine the single level of the public good, in this case SRD restoration level, and the associated cost, if they were to be combined. If this is the case, then the survey responses risk not being representative of truthful revealed preferences.

Another mechanism used to mitigate hypothetical bias was the inclusion of "inferred valuation" questions, which ask them what they think others would pay for the good rather than asking what they themselves would pay. This approach is designed to reduce social desirability or the tendency of a respondent to give a socially acceptable answer.

In order to address concerns of hypothetical bias, the following information was provided to respondents in the survey prior to the valuation questions:

(i) "*Your opinions are important to understand what Saskatchewan River Delta future outcomes the public prefers. The results of this survey are advisory. The survey will inform policymakers on the opinions and preferences of Canadians to help decide if and what actions should be taken that affect the delta.*

(ii) *There is no right or wrong answer. We have found some people support these alternatives and others do not support them. Both kinds of people have good reasons for why they would choose one way or the other.*

(iii) *It is important that you make each of your upcoming selections like you would if you were **actually** facing these exact choices in reality.*

(iv) *Please treat each of the following questions individually as a separate choice.*

(v) *Remember, paying for environmental improvement means you would have less money available to buy other things."*

Two possible reasons for hypothetical bias, specifically overestimation and underestimation of the willingness to pay values are the presence of yea-saying and protest responses. As implied by the term "yea-sayers", these respondents agree with valuation questions regardless of content and exhibit this behaviour because of the moral satisfaction or the utility that they receive from stating a willingness to pay and not for the change actually being valued (Andreoni, 1989; Blamey et al., 1999). Yea-saying has the potential to increase WTP estimates because respondents select alternatives with higher costs than they would actually pay. In contrast, nay-sayers would vote against a SRD restoration program they actually support for reasons that are not related to the attributes of the program presented in the valuation question, and therefore always select the status quo alternative. By implied definition, the presence of nay-sayers or protest votes usually results in lower WTP estimates.

In order to minimize the presence of protest responses and yea-sayers, the survey did not include emotionally capturing images to describe the deterioration of the delta. This was done to avoid the overemphasis of the urgent need for restoration and as a result the influence of respondents' responses. Also, several follow-up debriefing questions (i.e. questions at the end of the survey that ask respondents what they felt our thought as they read text or answered questions) (Johnston et al., 2017; Pattison, 2009; Sverrisson et al., 2008) were used to identify protest responses and yea-sayers. Researcher's judgment also plays a role in selecting the debriefing questions to investigate the potential presence of these two issues. Ultimately, identification of protest responses and yea-sayers required that I use subjective judgements as there are frequently no clear-cut decision rules or criteria for such identifications.

While it is acknowledged in the stated-preference literature that DCE and contingent valuation data potentially include misleading responses that might bias the welfare measures, there is no established procedure with a sound conceptual basis for excluding specific responses. One of the major challenges with excluding a respondent who respond in certain ways to the follow-up questions used for the purpose of identifying misleading responses is that the responses to these follow-up questions cannot be assumed exogenous to responses to the valuation questions (Champ et al., 2003). An alternative perspective to the approach often used in DCE studies to exclude these respondents from the final analysis is that protest responses should not be treated as faulty data and thus excluded from the econometric analysis. They should rather be considered useful in identifying specific design elements of environmental programs that can provide richer information to decision-makers and producer greater public support (García-Llorente et al., 2011).

When dealing with misleading responses it is recommended to address how much of an effect they actually have on estimates of central tendency (Champ et al., 2003). In other words, it is important to examine if respondents who behave strategically or more generally provide protest responses constitute only a small segment of the sampled population. Johnston et al. (2017) recommend that follow-up analysis need to be used to identify protest responses' effects when they are influential and distort welfare estimates, but every analysis need not evaluate all possible anomalies. If these types of responses are not of a magnitude to influence sample statistics and they merely add random noise to welfare estimates (Johnston et al., 2017; Marwell & Ames, 1981), they should not be excluded from the main analysis.

The following sections review the conceptual framework and statistical techniques used for the analysis of the DCE survey responses. Discussion will be provided on the Random Utility Theory (RUT), econometric models used to estimate model parameters and welfare analysis.

4.3 Random utility model theory

The conceptual framework of DCE responses is based on the RUT, which posits that people make choices to maximize their well-being or utility subject to constraints, and their utility of a good can be assigned to attributes characterizing that good. This framework is one of the most popular models economists use to study individual decision-making for discrete-choice preferences (McFadden, 1973). RUT assumes that an individual will choose the alternative among j alternatives that gives them the maximum possible utility over the available choice set. An individual i will choose an alternative j if and only if the associated utility with that specific alternative is greater than any alternative k, that is $U_{ij} > U_{ik}$ (Train, 2002).

The utility U_{ij} has two components, (i) a deterministic component V_{ij}, which corresponds to explainable and observable factors of choice such as attributes and their associated levels, and (ii) a stochastic component captured in ε_{ij}, which includes unexplainable factors of choice (e.g., unobserved characteristics of the individual, measurement errors, or alternative's characteristics omitted by the researcher). U_ij can, hence, be defined as follows:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad \text{Equation 4-1}$$

If utility is linear[28], which is the assumption applied in this study, utility an individual derives from a good which consists of certain attributes of a specific level can be expressed as follows:

$$U_{ij} = U\left(M_i, p_{ij}, x_{ij}, \varepsilon_{ij}\right) = \beta x_{ij} + \lambda\left(M_i - p_{ij}\right) + \varepsilon_{ij} \qquad \text{Equation 4-2}$$

where M_i is the individual's *i* annual household income; p_{ij} is the price of the alternative *j* presented to respondent *i*; x_{ij} is a vector of attribute levels; β is a vector of taste parameters which captures what fraction of the individual's utility of a good is attributable to variables by x_{ij}; and λ represents the marginal utility of income (Adamowicz et al., 1997; Verbeek, 2004).

In the modelling framework, it is then assumed that the probability of choosing the alternative *j* such that it maximizes an individual's utility is as follows:

$$P_{ij} = Prob[\left(V_{ij} + \varepsilon_{ij}\right) > \left(V_{ik} + \varepsilon_{ik}\right) \forall j \neq k] = Prob[\left(\varepsilon_{ik} - \varepsilon_{ij}\right) > \left(V_{ij} - V_{ik}\right) \forall j \neq k] \qquad \text{Equation 4-3}$$

Given that respondents' choice rule is "select the alternative that has the highest utility", the probability of choosing the alternative *j* over alternative *k* is $P(U_{ij} - U_{ik} > 0)$. That means that the absolute levels of utilities U_{ij} and U_{ik} do not matter and are irrelevant to the respondents' decision-making behaviour, hence to our model. It is only differences in utility that matter and are considered in the analysis of responses.

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[28] Evidence from the DCE literature suggests that welfare estimates are sensitive to utility specifications (Bockstael & McConnell, 1980; Herriges & Kling, 1999; Shonkwiler & Shaw, 2003) resulting in errors in WTP values ranging from 4% to 10% (Kling, 1989). It is standard practice in the DCE to assume linear utility functions for attributes (Hoyos, 2010), unless explicit consideration of either theoretical or empirical evidence of nonlinear relationships in terms of ecological attributes is made. When the utility functions underlying the discrete choice model are assumed to be linear in nature, the model cannot represent any varying marginal utility of the levels of the explanatory variables. In other words, the first percent level of the provision of any of the ecological attributes (lake sturgeon, waterfowl, muskrat, and healthy habitat) provides the same benefit or utility as the 100th percent of them, meaning that the expected WTP estimates do not depend on initial conditions or provision levels. Thus, the marginal rate of substitution between changes in attributes and the monetary attribute is constant only in linear utility specification.

All choices between presented alternatives are made based on the difference between the price associated with each alternative and individual's income, which is constant across choices for an individual. Hence, because utility is linear in income M_i, this term drops out of the utility difference expression. This means that income effects, to the extent that they exist, are ignored (Champ et al., 2003).

Discrete choice models are usually specified with alternative specific constants (ASC) for either the programs or the SQ scenario to measure any remaining differences in utility between scenarios that is not captured by the attribute level changes. I specify the ASC for the SQ which represents the utility of choosing the status quo alternative when everything else is constant (Holmes & Adamowicz, 2003). A positive sign indicates a positive preference for the status quo, implying that respondents attach some positive utility to the status quo situation relative to the program even if attribute levels do not change. A negative sign on the SQ parameter, however, indicates that choosing the status quo decreases utility and respondents prefer to move away from the status quo situation (Adamowicz et al., 1998; Hanley et al., 2005).

4.4 Econometric models

I estimate a series of choice models, starting with the Multinomial Logit model (MNL) and then moving to more advanced models to address preference heterogeneity (MNL with interactions, Random Parameters logit model, and Latent Class model). All models were estimated using R software and *Apollo* package (Hess & Palma, 2021). Estimation was primarily done using maximum likelihood techniques, with the exception of the Random Parameters Logit model for which the maximum likelihood estimator is used instead.

In addition to the estimated parameters of the discrete choice model, *Apollo* reports a number of goodness-of-fit statistics, such as R-Squared (R^2), Adjusted R-Squared (Adjusted R^2), Akaike Information Criterion (AIC), and the Bayesian Information Criterion (BIC), which are fit-based strategies to choose among models based on how well each of the models fits the data. Also, Apollo reports the eigenvalue of the Hessian that is closest to zero, for which small values can indicate convergence issues, as well as the estimation time, the number of estimated parameters, iterations taken, starting and final log-likelihood, and depending on the model, the log-likelihood at zero values for all parameters (Hess & Palma, 2021).

4.4.1 Multinomial logit model

Econometric analysis of choice model data often begins with the use of multinomial logit (MNL) model[29] (Manski, 2001; McFadden, 1974). The MNL model is widely used in the field of discrete choice modelling due to the model's closed form specification which allows an increase in the ease and speed at which the model can be estimated. The advantage of MNL rests, to a large extent, on its simplicity of estimation (Champ et al., 2003).

The logit choice probabilities are derived using the formula outlined in Equation 4-4 on the probability that decision-maker i chooses alternative j over remaining available alternatives and making an assumption on the distribution of the error term. This model assumes that the errors terms e_{ij} are independently and identically distributed (IID) following a Type 1 extreme value or Gumbel distribution (Boyle et al., 2003; Hausman & McFadden, 1984; Manski, 2001). Algebraic manipulation[30] of that formula and the cumulative distribution over all $j \neq k$ alternatives results in the closed-form expression:

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_k e^{V_{ik}}} \qquad \text{Equation 4-4}$$

which is the logit choice probability. As required for a probability, P_{ij} takes values only between zero and one. With $\forall\, j \neq k$ held constant, as V_{ij} increases, indicating an improvement in the observed attributes of the alternatives, which in this study would translate into improvement of ecological attributes levels across restoration scenarios, P_{ij} approaches one. Additionally, the choice probabilities for all alternatives sum to one. This is directly related to the denominator in equation 4-5 being the sum of the number over all alternatives. Log-likelihood function with these choice probabilities is globally concave in parameters β, which helps in the numerical maximization procedures. Under the assumption of the utility being linear in parameters, the logit probabilities become

$$P_{ij} = \frac{e^{\beta x_{ij}}}{\sum_k e^{\beta x_{ik}}} \qquad \text{Equation 4-5}$$

The main limitations of the MNL model are related to its inability to capture unobserved heterogeneity, assumption of no correlation across choice sets from the same individual, and the IIA property. IIA property is particularly apparent as a weakness when

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[29] See (Louviere et al., 2000) for a more exhaustive list of reasons why the MNL model is the most widely used econometric model amongst practitioners.
[30] See (Train, 2002) for description of the algebra followed to derive the closed-form expression of the logit choice probability.

exploring problems with differential patterns of sustainability across alternatives. However, if the focus of the study is estimating average preferences rather than forecasting substitution patterns across alternatives, such as is the case in our study, IIA restriction is not a main concern. Incorrectly restricting preferences to be homogeneous when in fact preferences do vary across individuals will lead to biased estimates for any specific individual (Breffle & Morey, 2015). Therefore, accounting for preference heterogeneity can enhance the accuracy and reliability of parameter estimate, increase the explanatory power of the model and provide relevant information to policy makers about the distribution of public preferences (P. C. Boxall & Adamowicz, 2002; Colombo et al., 2009).

4.4.2 Treatment of heterogeneity

The attempt to circumvent all three of the above limitations of MNL and incorporate respondent's unobserved preference heterogeneity in economic analysis has triggered the use of other models, such as the random parameters logit (RPL) and the latent class (LC) approach (Train, 2002). As Train (2002) points out, these models allow to account for unobserved preference heterogeneity, correlation across alternatives and repeated choices.

Overall, identification and quantification of heterogeneous preferences within the population allows policy makers to obtain more accurate welfare estimates. This in turn allows them to gain insight into how policies targeting the improvement of the SRD ecological condition and changes in different ecological attributes affect different segments of the Canadian population.

4.4.2.1 MNL with interactions

Preference variation may have a systematic nature (observed preference heterogeneity), meaning that the respondents' preference variation can be linked to some observed variables such as socio-demographic characteristics, or be purely random (unobserved preference heterogeneity). One option that can be used when there is expectation that the unobserved portion of utility is correlated over alternatives is the re-specification of the utility function so that the source of the correlation is captured explicitly such that the remaining errors are independent. Such model is known as MNL with interaction terms. However, because it limits the treatment of heterogeneity across individual decision makers to interactions with respondent characteristics, such as income and age for example, potentially some share of heterogeneity will remain unexplained, due to intrinsic differences in preferences across respondents. Additionally, it is not feasible for a dataset to capture all relevant individual-specific characteristics that could explain differences in preferences. Also, it is challenging for the estimation procedure to interact each individual characteristic with each attribute.

4.4.2.2 Random Parameters logit model

The RPL model, also referred to as the mixed multinomial logit model, permits the estimation of unobserved preference heterogeneity or variation among respondents (Grafton et al., 2004; Train, 2002). This is achieved by assuming that the preference parameters in the utility functions vary across respondents according to an assumed probability distribution. Normal and log-normal probability densities are most commonly used to describe preference heterogeneity (Train, 2002). The lognormal distribution is useful when the coefficient is known to have the same sign for every decision maker, such as cost coefficient is known to be negative for everyone in a mode choice situation. Other distributions that can be used as a density function include uniform, triangular, and gamma. The utility obtained by an individual *i* from choosing an alternative *j* is quantified as:

$$V_{ij} = SQ_{ij} + \beta_i x_{ij} + \varepsilon_{ij} \qquad \text{Equation 4-6}$$

where the interpretation of each term is the same as in the MNL model, with the difference that β_i and SQ_{ij}vary among people rather than being fixed (Train, 2002). The mixed logit probability is the integral of the following equation over all possible variables of β_i.

$$P_{ij} = \int \left[\frac{e^{\beta` x_{ij}}}{\sum_{k=1}^{k} e^{\beta` x_{ij}}} \right] f(\beta|\theta) \partial\beta \qquad \text{Equation 4-7}$$

where f(β) is assumed to be normally distributed in our model (Carlsson et al., 2003; Train, 2002), and θ refers collectively to the parameters of this distribution. The RPL probability is a weighted average of the logit formula, called a mixed function, evaluated at different values of β, with the weights given by the density $f(\beta)$, called the mixing distribution. When the mixing distribution is degenerate at fixed parameters *b*: $f(\beta)$ = 1 for β = b and zero for $\beta \neq$ b, the choice probability in equation (4-7) becomes the simple MNL logit formula expressed in equation (4-6).

RPL model is well suited to simulation methods for estimation. The probabilities are approximated through simulation for any given value of θ using the following approach:

(1) Draw a value of β from $f(\beta|\theta)$, and label it β^r with the superscript r=1 referring to the first draw;

(2) Calculate the logit formula $\left[\frac{e^{\beta` x_{ij}}}{\sum_{k=1}^{k} e^{\beta` x_{ij}}}\right](\beta^r)$with this draw;

(3) Repeat steps (1) and (2) many times, and average the results, which gives the simulated probability as following:

$$\check{P}_{ij} = \frac{1}{R}\sum_{r=1}^{R}\left[\frac{e^{\beta` x_{ij}}}{\sum_{k=1}^{k} e^{\beta` x_{ij}}}\right](\beta^r) \qquad \text{Equation 4-8}$$

where R is the number of draws. The specification can be generalized to allow for repeated choices by each sampled decision-maker. The only difference between a RPL with repeated choices and that with only one choice per decision-maker is that the integrand in equation (4-8) involves a product of logit formulas, rather than just one logit formula. The logit formula is calculated for each period, and the product of these logits is taken. This process is repeated for 500 draws in this study and the results are averaged. The simulated probabilities are inserted into the log-likelihood function to give a simulated likelihood:

$$SLL = \sum_{i=1}^{I}\sum_{j=1}^{J} d_{ij} ln\check{P}_{ij} \qquad \text{Equation 4-9}$$

where d_{ij}=1 if individual *i* chooses alternative *j* and zero otherwise. The maximum simulated likelihood estimator (MSLE) is the value of θ that maximizes SLL.

To obtain the results from the RPL model, I used a simulation likelihood with 500 Halton draws. Halton draws procedure offers the potential to take an “intelligent” draws from the mixing distribution rather than random ones, therefore reducing the simulation error that is associated with a given number of draws. A large number of draws is needed to assure reasonably low simulation error in the estimated parameters (Train, 1999).

By accounting for the heterogeneity of preferences, RPL will provide a potentially richer description of preferences than the MNL model and help to enhance the reliability and accuracy of the welfare estimates (Hoyos, 2010). Previous studies have demonstrated that the RPL model is superior to the multinomial logit models in terms of welfare estimates and the overall fit (Dias & Belcher, 2015; Layton & Brown, 2000; Lusk, 2002; Morey & Greer Rossmann, 2003). The main drawback of the RPL model is the fact that the integrals representing the choice probabilities expressed in the above equations do not have a closed-form expression and need to be approximated through simulation (Hess & Polak, 2005; Train, 2002).

The decision whether the coefficients of the RPL model should be correlated or not when employed to analyse DCE is often based on a trade – off between:

(i) the uncorrelated RPL’s deficiency to allow for any source of correlation, be it behavioural form or scale heterogeneity;

(ii) the computational complexity; and

(iii) the non-trivial interpretation of the model output generated from the correlated RPL model (Mariel & Artabe, 2020).

However, the limitation of the uncorrelated RPL model of not capturing the correlations among coefficient leads to biased WTP values (estimated distributions of ratios of coefficients) making it justifiable for the researcher to employ the correlated RPL model, despite the challenges associated with the later. Due to allowing for the correlation among the parameters, the correlated RPL model prevents the scale heterogeneity from being absorbed by the estimated preference parameters (Mariel, Demel, et al., 2021).

The RPL models, both uncorrelated and correlated, used in this study assume a normal distribution. This means that the model allowed respondents to have positive and negative preferences for SRD attributes. All the alternative-related ecological attributes and the SQ attribute were specified as randomly distributed, except for the monetary attribute which was specified as fixed.

First, assuming that preference parameters are uncorrelated with each other, uncorrelated RPL model is employed. For this model, there are two coefficients estimates for each of the random parameters, where the first is an estimate of the mean preference and the second is an estimate of the standard deviation of preferences across the sample. No constraint was applied on the signs of the ecological attributes with random parameters, as recommended by Train (2002).

Next, correlated RPL model was employed. Again, in addition to the alternative-related ecological attributes, status quo parameter was also specified as randomly distributed, leaving the monetary attribute the only fixed attribute.

4.4.2.3 Latent Class Logit Model

The latent class (LC) logit model is also used to investigate preference heterogeneity. This model assumes that individuals belong probabilistically to different groups. The latent class model assumes that the population consists of *S* total preference classes where each respondent has a non-zero probability of falling into every class, thus allowing for random heterogeneity in preferences. A separate MNL model is estimated for each class, implying a separate set of preference parameters. The way in which a respondent belongs to a class is not determined by the analyst, but is estimated alongside all other model parameters. Membership in a specific class or the probability that an individual will be in class *S* can be estimated as a function of individual-specific characteristics of the respondent. The preference class probabilities must sum to 100%. Each class is characterized by its unique and homogeneous-within-class preferences β_S, *s=1,2,…,S*. Each individual's choice set on the r[th] occasion is C_{ir}, *r=1,2,…,R*. Because the individual's class membership cannot be observed, i.e. it is latent, a two-stage model is developed to derive the probability of observing the choice of alternative *j:* a choice model conditional on class membership, plus a class membership model, shown in equation (4-10).

$$P_{irj} = \sum_{s=1}^{S} P_{irj|s} W_{is} \qquad \text{Equation 4-40}$$

where $P_{irj|s}$ is the probability of choice conditional on membership in segment of class s, and W_{is} is the probability individual *i* belongs to class *s*.

Assuming that the conditional utility functions exist for each class *s* and the stochastic utilities within each class are independent Gumbel variates with scale μ_s >0, *s*=1,…,S, I get the following formula (equation 4-11) on the conditional choice probability:

$$P_{irj|s} = \frac{\exp(\mu_s V_{irj|s})}{\sum_{j \in C_{ir}} \exp(\mu_s V_{irj|s}} \qquad \text{Equation 4-51}$$

Thus, within segment preference is characterized by the IIA property inherent to the MNL model.

The process for developing the probabilistic classification model W_{is}, explained thoroughly by Kanninen and Bateman (2006) results in the following class assignment probabilities (equation 4-12)

$$W_{is} = \frac{exp\ (\lambda \Gamma'_s Z_i)}{\sum_{s'=1}^{S} exp\ (\lambda \Gamma'_s Z_i)} \qquad \text{Equation 4-62}$$

where Z_i is the vector of individual decision-maker variables (socio-demographics, attitudes, perceptions, etc.) that affect classification probabilities; Γ'_s is a segment-specific parameter vector, and λ is a positive scale factor associated with the error terms being IID Gumbel specified. The joint use of Equation 4-12 and 4-11 in Equation 4-10 constitutes the full model describing a single choice.

The optimal number for S different latent classes is defined using an iterative model fitting exercise. The LC model usually starts with S=2 classes and then increases S until no significant further gains in model fit or behavioural insights is obtained. Although no rigorous method exists to select the optimal number of latent classes, there are various goodness of fit measures for the models with the different numbers of latent classes which are widely accepted as a tool for this purpose (Cavanaugh & Neath, 2019), such as the Bayesian Information Criterion (BIC) or the Akaike Information Criterion (AIC). This goodness of fit measures can be used in addition to researcher judgement of model interpretability. However, it should be noted that, because class assignment is based on probabilities, proper class assignment is not fully guaranteed as well as the exact number or percentage of sample members within each class cannot be determined (Kanninen & Bateman, 2006). This is one of the main limitations that need to be considered when employing LC model.

This study has used an iterative process to test several configurations and determine the appropriate number of classes. Three LC models (S1=2 classes; S2= 3 classes; S3=4 classes) have been run to select the final model used for further analysis. In addition to the ecological attributes and the monetary attribute, covariates have been included in each of the models that are compared. Including covariates allows answering an important question – *"Does the composition of the classes differ by characteristics?"*. This analysis is helpful to find the source of heterogeneity among class memberships. I included the following respondent characteristics: "male", "prairies", "high income", "high education" and "People age 45 and older", explained previously in this chapter.

4.4.3 Welfare Measures

4.4.3.1 Marginal welfare measures

The concept of MWTP is defined as the marginal rate of substitution between the attribute and the price attribute in the utility function. Combination of alternatives and respondent characteristics with the marginal utility of income parameter, which is assumed constant over the range of available alternatives, is used to estimate WTP for river delta restoration programs (Haab & McConnell, 2002). The WTP estimates obtained for any improvements in ecological attributes using the choice experiment approach are based on the implicit prices for alternative ecosystem services choices given that other factors remain constant (Do & Bennett, 2009). By estimating the marginal rate of substitution between two attributes that characterize the good, insights can be obtained into the trade-off between the two of them and thus the mutual importance of the attributes in question (Blamey et al., 2002). When one of the attributes is a cost attribute and the attributes enter the utility linearly, comparing (dividing) the two attributes determines the MWTP, also known as part-worth, as follows:

$$WTP = -\left(\frac{\beta_{attribute}}{\beta_{cost}}\right) \quad \text{Equation 4-13}$$

where $\beta_{attribute}$ and β_{cost} are the corresponding parameters of the attribute of the interest and the cost attribute, respectively.

In this study, I estimate how much respondents are willing to pay, in the form of an annual tax, for a 1% increase (improvement) in the level of each of the attributes, hence I measure MWTP. For example, a WTP for increasing the level of lake sturgeon population would be given by ($\frac{\beta_{lake\,sturgeon}}{\beta_{annual\,tax}}$), showing the amount of money respondents would be willing to pay annually for 20 years to increase the population level of lake sturgeon by one unit (i.e. one percentage point). Differences in the magnitude of the MWTP values for each of the attributes indicate the strength of respondent preferences for the attributes expressed in Canadian dollars.

It is worth noting that the MWTP does not take into account the utility that respondents gain from moving away from the status quo option. Instead, this utility is captured by the parameter coefficient of the ASC variable (Boxall et al., 2009), included in the utility functional forms in each model.

With a non-linear utility function, the WTP is no longer constant and can only be stated subject to the given values of the other attributes. In nonlinear specifications, the marginal rate of substitution varies depending on the size of the utility difference caused by the change in attribute. This means that WTP for a 1% increase in the level of an attribute is no longer the same as the reference point (base) level of the attribute increases. For instance, MWTP for a 1% in the level of lake sturgeon from 35% (SQ scenario level) to 36% is not the same as WTP for a 1% increase in its level from 60% to 61%. Different hypotheses generated by economic theory and goodness of fit measures can be used to inform which functional form is more appropriate for a specific study context. This study assumes a linear utility function because no evidence is drawn from other existing studies in river delta non-use values estimation regarding a specific shape of marginal utility-provision level of the ecological indicators (i.e. diminishing returns to improved level of provision).

4.4.3.2 Compensating Variation

One of the strengths of DCE is its ability to evaluate various alternatives depicting different conditions/states of a good or service, due to the attribute levels differences. Including a monetary (cost) attribute in the choice set makes it possible to monetize welfare measurements to evaluate improvements in the quality and quantity of the good (service). Welfare measures enable the researcher to undertake analysis that measures changes in welfare related with a specific policy. Two types of welfare measures exist: welfare measures derived from the Hicksian demand curve (compensating and equivalent variation) and consumer surplus derived from the Marshallian demand curve.

Using its definition, compensating variation (CV) measures “a change in the level of provision in the attribute or attribute by weighting this change by the marginal utility of income" (Hoyos, 2010), can be calculated (Hanley & Barbier, 2009). In other words, it measures the amount of monetary compensation required to be taken from (or given to) an individual to make him as well of *(i.e. keep him at the initial state utility level)* with the change of the attribute levels as they were without the change *(i.e. indifferent between the new and initial state).* This implies

$$U^0\left(Income, p^0, x_j^0\right) = U^1\left(Income - CV, p^1, x_j^1\right) \qquad \text{Equation 4-14}$$

where U^0 denotes the initial utility level and U^1 denotes the utility after the change from level x_j^0 to x_j^1.

Assuming that the price function is linear and that the marginal utility of money is constant, income cancels out and hence there is no income effect (Equation 4-15).

$$U_{ij}^0 = \beta x_{ij}^0 + \lambda\left(M_i - p_{ij}^0\right) = \beta x_{ij}^1 + \lambda\left(M_i - p_{ij}^1 - CV\right) = U_{ij}^1 \qquad \text{Equation 4-75}$$

In the context of this study, CV represents the amount of income that must be taken away from respondents in the form of annual taxes at the new improved levels of attributes chosen (i.e. lake sturgeon, muskrat abundance, waterfowl population, and overall habitat in healthy ecological condition) so that they are as well off as they were at the status quo attribute levels. Following Hanemann (1984), the following formula (Equation 4-16) is used to estimate CV in the study:

$$CV = -\frac{1}{\beta_{cost}}\left[U_{ij}^1 - U_{ij}^0\right] \qquad \text{Equation 4-86}$$

where β_{cost} is the parameter of the cost attribute.

4.4.3.3 Non-marginal welfare measures

In addition to understanding the welfare implications of marginal changes, one main interest of researchers is deriving the monetary value of a change in the quantity (quality) of a good because of a policy intervention. Such cases usually involve reasonable one-marginal changes in multiple attributes simultaneously. I apply the concept and formula of compensating variation to the linear utility function for each of the alternatives which takes the explicit form as following:

$$V\left[[alternative]\right] = b_{statusquo} + b_{cost} * cost + b_{lakesturgeon} * lakesturgeon + b_{waterfowl} * waterfowl + b_{muskrat} * muskrat + b_{wetland} * healthyhabitat \qquad \text{Equation 4-17}$$

Then, the formula for calculating this welfare measure is described in Equation 4-18:

$$CV = -\frac{1}{\beta_{cost}}\left[\beta_{status\ quo} + \beta_{Sturgeon}\left(sturgeon_{Scenario} - sturgeon_{SQ}\right) + \beta_{waterfowl}\left(waterfowl_{Scenario} - waterfowl_{SQ}\right) + \beta_{muskrat}\left(muskrat_{Scenario} - muskrat_{SQ}\right) + \beta_{habitat}\left(habitat_{Scenario} - habitat_{SQ}\right)\right]$$

Equation 4-98

This study also briefly explores the effect of using different specifications of the utility function on the welfare estimates. For this purpose, an MNL model with log-linear-in parameters RUM specification for each alternative is estimated. Then, the MWTP are used to calculate the CV by implementing the following formulas (Equations 4-19 and 4-20).

$$\beta_{status\ quo} + \beta_{Sturgeon}\log(sturgeon_{SQ}) + \beta_{waterfowl}\log(waterfowl_{SQ}) + \beta_{muskrat}\log(muskrat_{SQ}) + \beta_{habitat}\log(habitat_{SQ}) = -\beta_{cost}(CV) + \beta_{Sturgeon}\log(sturgeon_{Scenario}) + \beta_{waterfowl}\log(waterfowl_{Scenario}) + \beta_{muskrat}\log(muskrat_{Scenario}) + \beta_{habitat}\log(habitat_{Scenario}) \quad \text{Equation 4 - 19}$$

OR

$$CV = -\frac{1}{\beta_{cost}}\left[-\beta_{status\ quo} + \beta_{Sturgeon}\log\left(\frac{sturgeon_{Scenario}}{sturgeon_{SQ}}\right) + \beta_{waterfowl}\log\left(\frac{waterfowl_{Scenario}}{waterfowl_{SQ}}\right) + \beta_{muskrat}\log\left(\frac{muskrat_{Scenario}}{muskrat_{SQ}}\right) + \beta_{habitat}\log(habitat_{Scenario}/habitat_{SQ})\right] \quad \text{Equation 4-20}$$

Results of this model and how the CV estimates compare to those derived using the selected final econometric model are presented in the Results and Discussion chapter.

Chapter 5: RESULTS AND DISCUSSION

5.1 Introduction

The previous chapters provided the theoretical and research background to estimate the economic benefits of improving the ecological condition of the Saskatchewan River Delta. The aim of this chapter is to present the results of the econometric models described above. This chapter begins with the estimation of different econometric models based on responses to the survey questions, together with an interpretation of the results. Following this, compensating variation estimates associated with various levels of SRD restoration are presented and discussed. Next, I test the sensitivity of results to the potential presence of bias (yea-sayers and protest responses). Finally, information on the respondents' opinion on the survey, SRD ecological significance and other aspects are provided. Results presented in these sections provide the context needed to understand the motivations and factors that influence respondents' preferences for the delta's ecological improvement.

5.2 Valuation results for Saskatchewan River Delta

5.2.1 Multinomial logit model results

I start the empirical analysis with the estimation of the multinomial logit model (MNL). MNL helps to show the importance of the attributes in explaining respondents' choices across the three different options in a choice set: the status quo and the two restoration alternatives. Table 5-1 shows the MNL parameter results. The parameter estimates for the ecological attributes lake sturgeon, waterfowl population, muskrat abundance, habitat in healthy ecological condition) are presented for 1% change in their level of abundance (provision). For instance, 1% increase in the level of lake sturgeon positively influences respondents' utility level by 0.68. Similar interpretation holds true for the other attributes. Parameter estimates for all four ecological attributes are positive, as expected, and statistically significant at the 1% level. The statistically significant and negative value of the coefficient for the status quo parameter indicates a preference of people to move away from status quo for an improvement, but it is not related to a specific program attribute (i.e. all attribute levels are the same). The negative estimated coefficient on the monetary attribute indicates that as the cost or associated annual tax of the proposed restoration alternative increases, holding all other attributes constant, the probability of choosing that alternative decreases. In other words, the larger the tax, the more likely respondents are to dislike the restoration alternative associated with that monetary amount. This parameter can be interpreted as the negative of the marginal utility of income.

The third column of Table 5-1 shows the MWTP value estimates for non-monetary attributes. The attribute ‘habitat in healthy ecological condition’ seems to have been considered as the most important by respondents, based on the coefficient value representing the highest MWTP. Respondents are willing to pay $2.32 for 1% increase in the overall habitat area in healthy ecological condition. The attribute ‘muskrat abundance’ seems to have been accorded the lowest preference by respondents. On average, respondents are willing to pay $1.63 for 1% increase in the level of muskrat abundance, moving the population level closer to the conservation target. It should be noted that the differences of MWTP across ecological attributes are not significantly different. It is important to note that because of the linear specification of the utility function, explained in the Methods Chapter, the WTP for differences in attribute levels is additive. For example, in the case of muskrat abundance, this implies that people would be willing to pay $16.30 for a 10% increase in its level. The same interpretation holds true for the other attributes.

Table 5-1 Multinomial logit parameter and MWTP estimates

Attributes	Parameter (standard errors)	MWTP (standard errors)
Status Quo	-0.18** (0.04)	
Lake sturgeon (%)	0.68*** (0.05)	$1.84 (0.18)
Waterfowl population (%)	0.65*** (0.06)	$1.74 (0.19)
Muskrat abundance (%)	0.61*** (0.07)	$1.63 (0.21)
Habitat in healthy ecological condition (%)	0.86*** (0.08)	$2.32 (0.26)
Cost (Annual Tax)	-0.37*** 0.02)	
Number of individuals	965	
Number of choices	5790	
Number of parameters	6	
Log-likelihood	-5934.01	
McFadden R squared	0.0547	
BIC	11920	

Note: ***, ** indicate statistical significance at the 0.01 and 0.05 respectively. Parameter estimates are the change in the utility level associated with a one-unit change of the attributes, all other predictors being held constant. Standard error for each parameter and MWTPs is presented in parentheses. WTP is measured for a 1% increase in the total estimated size or level of each ecological attribute.

5.2.1.1 Comparison of preferences between respondents residing in the Prairies and those residing in the rest of Canada

To investigate whether respondents in the Prairies have different preferences for the restoration of the delta, two other MNL models were estimated. Table 5-2 provides a comparison between Model 2 which uses the subsample of respondents residing in either Saskatchewan, Manitoba, or Alberta (N1=231) and Model 3 which uses the remaining subsample (N2=734).

Table 5-2 MNL models comparison for the subsample of Prairie Provinces residents and the remaining of the sample

Attributes	Model 2 Only residents in SK, MB, AB		Model 3 Residents in the remaining provinces and territories	
	Parameter (standard errors)	MWTP (standard errors)	Parameter (standard errors)	MWTP (standard errors)
Status Quo	-0.15 (0.09)		-0.18*** (0.05)	
Lake sturgeon (%)	0.60*** (0.11)	$1.08 (0.21)	0.72*** (0.06)	$2.23 (0.25)
Waterfowl population (%)	0.79*** (0.13)	$1.40 (0.25)	0.63*** (0.07)	$1.93 (0.25)
Muskrat abundance (%)	0.78*** (0.14)	$1.40 (0.29)	0.57*** (0.07)	$1.74 (0.25)
Habitat in healthy ecological condition (%)	0.91 *** (0.16)	$1.64 (0.35)	0.87*** (0.09)	$2.68 (0.35)
Cost (Annual Tax)	-0.55*** 0.04)		-0.33 *** (0.02)	
Number of individuals	231		734	
Number of choices	1386		4404	
Number of parameters	6		6	
Log-likelihood	-1380.801		-4529.811	
McFadden R squared	0.0932		0.0638	
BIC	2805.01		9109.96	

Note: *** indicates statistical significance at the 0.01level.

From the comparison of Model 2 and Model 3, a few points can be made in terms of preference differences between respondents residing in the Prairie Provinces and those that reside anywhere else in Canada. The attribute ‘lake sturgeon’ seems to have been considered the least important for Prairie Provinces residents, who would pay $1.08 for a 1% increase in its population level. Residents in the rest of Canada assign a higher value to this attribute as they are willing to pay $2.23 for a 1% increase in sturgeon population level. On the contrary, the highest MWTP for both groups is associated with habitat in healthy ecological condition, which is reported at $1.64 for residents in the Prairies and at $2.68 for the remaining provinces. The status quo coefficient for Prairie Provinces subsample is not statistically significant.

Overall, Prairie Provinces residents seem to be willing to pay less for the improvement of each of the attribute levels included in the choice sets compared to the rest of the sample. One possible reason for the lower MWTP values for Prairie respondents might be that the people living in the Prairies have also been thinking more about impacts that the restoration alternatives would have to their lives and economic activity if the restoration plans were implemented. No recent data is available on the economic costs associated with the restoration of the SRD. However, considering the various economic uses of the water from the Saskatchewan Rivers *(hydropower production, municipal and industrial water supply, irrigation, etc.)*, listed in the survey, and the trade-offs associated with the restoration of the delta, it can be inferred that the cost estimates are very high and incurred by different stakeholders *(farmers, industry, general public because of municipal use of water and hydropower, etc.)*.

5.2.2 RPL models, uncorrelated and correlated

This section and the following one examine the results from models that relax the standard multinomial logit assumption of preference homogeneity, starting with the random parameters model, uncorrelated and correlated, to then move to the latent class model.

Table 5-3 displays the parameter estimate results of the uncorrelated and correlated RPL models. All parameter estimates for both models were significant at the 1% level and the signs agreed with my expectations. The estimated standard deviations of coefficients are highly significant, with the exception of the one for waterfowl population, indicating that preferences for the ecological attributes do indeed vary in the sample. The magnitudes of the estimated standard deviations are reasonable relative to the estimated means. Overall, the results obtained from the RPL models showed that the respondents were willing to pay an annual tax for 20 years to move away from the “status quo” or “leave as it is “ condition of the SRD if all other factors remained constant. The signs of the status quo and cost parameters are negative as in the MNL model.

Based on the obtained magnitude of standard deviations, for both models, the highest degree of preference heterogeneity is observed for habitat in healthy ecological condition.

Whereas the least evident preference heterogeneity is observed for waterfowl population and muskrat abundance across models, deviations which are not significant. A possible explanation for this result might be related to variation in perception of what ecological restoration for habitat in healthy ecological condition entails. With respect to this attribute, the restoration program is most likely large-scale and subject to varying interpretation of what the process to the historic trajectory of 900,000 hectares of restored habitat would look like. Additionally, respondents might have different expectations on the feasibility of the restoration of this attribute as compared to the more straightforward species-targeted restoration (waterfowl and muskrat abundance), which affect their preferences for each of the attributes.

For the correlated RPL model, results from Table 5 – 3 show that there is a high degree of correlations between the random parameters. In particular, there are two very large positive correlations. These are *lake sturgeon – muskrat abundance* and *waterfowl population – muskrat abundance.* The sign and magnitude of these correlations indicates that respondents who are in favour of increasing the population level of lake sturgeon also strongly prefer an increase in the muskrat abundance, and vice versa. Similarly, respondents with a preference for the waterfowl population are likely to also prefer an increase of the muskrat abundance level. Also, there is a positive correlation between *lake sturgeon – waterfowl* population. A plausible reason for this is people's preferences to restore endangered species in general because they maintain the health of the ecosystem, without having a strong preference for one in particular. Another possible explanation is that people might expect that for a restoration of the SRD ecosystem to happen, the restoration of all endangered species must occur simultaneously. On the other hand, regarding the correlation of the habitat in healthy ecological condition attribute with the other non-monetary attributes, the only positive correlation is noticed with respect to lake sturgeon. The correlations *habitat in healthy ecological condition – muskrat abundance* and *habitat in healthy ecological condition – waterfowl population* are negative, but not statistically significant. The negative correlation might be related to the possibility that people might view restoring habitat and restoring threatened species as overlapping actions. In other words, they might expect that habitat restoration will lead to threatened species (muskrat abundance and waterfowl population) restoration as well. If this is the case, it makes sense for them, to prefer one or the other but not both.

Table 5-3 Uncorrelated and Correlated Random Parameter Logit model results

Attribute	Uncorrelated RPL Parameter (standard error)	Correlated RPL Parameter (standard error)
	Mean for non-random parameters	
Cost (Annual tax)	-0.46*** (0.02)	-0.47*** (0.02)
	Mean for random parameters	
Status Quo	-1.62*** (0.18)	-1.58*** (0.17)
Lake sturgeon (%)	0.87*** (0.07)	0.91*** (0.07)
Waterfowl population (%)	0.82*** (0.07)	0.82*** (0.08)
Muskrat abundance (%)	0.72*** (0.084)	0.74*** (0.09)
Habitat in healthy ecological condition (%)	1.02*** (0.09)	1.13*** (0.07)
	Standard deviations for random parameters	
Status Quo	-4.02*** (0.21)	3.96*** (0.21)
Lake sturgeon	0.82*** (0.12)	1.08*** (0.11)
Waterfowl population	0.13 (0.14)	0.61*** (0.17)
Muskrat abundance	-1.04*** (0.15)	0.47 (0.31)
Habitat in healthy ecological condition	1.11*** (0.20)	1.33*** (0.20)
	Correlations coefficients for random parameters	
Lake sturgeon X waterfowl population		0.55*** (0.14)
Lake sturgeon X muskrat abundance		0.99*** (0.16)
Lake sturgeon X habitat in healthy ecological condition		0.50* (0.21)
Waterfowl population X muskrat abundance		0.77** (0.24)
Waterfowl population X habitat in healthy ecological condition		-0.20 (0.21)
Muskrat abundance X habitat in healthy ecological condition		-0.34 (0.38)
Number of individuals	965	965
Number of choices	5790	5790
Number of parameters	11	17
Log-Likelihood	-4723	-4685
McFadden Pseudo R-squared	0.24	0.25
BIC	9541	9517

Note: ***, **, * indicate statistical significance at the 0.01, 0.05, and 0.1 level, respectively.

The BIC value is lower in the correlated RPL model than in the uncorrelated one, indicating a better fit for the later model. Similarly, the McFadden's Pseudo R-squared is higher, although slightly different, in the correlated RPL model, again indicating a better fit.

Comparing the results of RPL models with those obtained from MNL model, I can conclude that the RPL model specifications show a significantly better fit (BIC in MNL: 11920; BIC in uncorrelated and correlated RPL models: 9541 and 9517 respectively; McFadden Pseudo R^2 in MNL: 0.05; McFadden Pseudo R^2 in uncorrelated and correlated RPL models: 0.24 and 0.25 respectively). Furthermore, significant standard deviation parameters are estimated for many of the attributes and the SQ indicate the presence of unobserved heterogeneity in preferences, which the MNL model does not capture.

Next, MWTP estimates are calculated for both uncorrelated and correlated RPL models. The magnitudes are similar across the two models. Table 5–4 shows that respondents are willing to pay the highest amount of money per year for one unit/level of improvement of the habitat in healthy ecological condition while other factors remain constant, that is between \$2.29 - 2.40, moving from uncorrelated to correlated RPL. On the other hand, the lowest MWTP was found for muskrat abundance, which falls in the range of \$1.55 - \$1.62 per year for one unit improvement on the muskrat abundance, across the two models. Overall, the two models converge to very similar median WTP values for each of the attributes and the findings seem to be relatively robust.

Table 5-4 Marginal willingness to pay for the ecological attributes using uncorrelated and correlated RPL models

	Uncorrelated RPL		Correlated RPL	
SRD ecological attributes	MWTP	95% Confidence Interval	MWTP	95% Confidence Interval
Lake sturgeon (%)	\$1.95	(\$1.64 ~ \$2.25)	\$1.93	(\$1.62 ~ \$2.25)
Waterfowl population (%)	\$1.84	(\$1.52 ~ \$2.15)	\$1.73	(\$1.39 ~ \$2.09)
Muskrat abundance (%)	\$1.62	(\$1.25 ~\$ 1.98)	\$1.55	(\$1.18 ~ \$1.93)
Habitat in healthy ecological condition (%)	\$2.29	(\$1.84 ~ \$2.76)	\$2.40	(\$1.94 ~ \$2.88)

As usual, the magnitude of the coefficients is not directly comparable across models. However, they lead to similar conclusions regarding their signs and statistical significance. RPL models results confirmed the MNL model's insight that increasing the level of the overall habitat in healthy ecological condition was the most desirable SRD ecosystem service for the sampled respondents as compared to the muskrat abundance, which has the lowest MWTP associated with it.

5.2.3 Latent Class Model

5.2.3.1 Process followed for the selection of LC model with 2 classes

Table 5-5 shows several model fit characteristics for LC models estimated with 2, 3, and 4 classes. The convergent log-likelihoods and pseudo R^2 increase as the number of latent classes increases from 2 to 3, which confirms the existence of heterogeneous preferences among respondents. Additionally, to determine the optimal number of latent classes and hence the LC model to use for further analysis, the AIC and BIC goodness of fit measures are compared. AIC has the lowest value for the 3-class model. Also, based on the lowest value of the BIC, which is argued to produce the most stable results given a stable sample size and a limited number of latent classes, the model preferred by this fit index seems to be the 3-class model.

However, as is the case in this study, to determine the optimal number of classes in the latent class model, the goodness-of-fit measures are not sufficient alone. Judgement of the researcher is also needed. Although based on these measures, 3-class model is indicated to be the preferred one, it needs to be highlighted that the price coefficient for one of the classes is positive, implying that respondents that fall in this class are not price sensitive. Because WTP is the maximum price a consumer is willing to pay for a product or service, for this class does not make sense to calculate this estimate. Also, although the 4-class converged using Apollo package, the standard errors for the output showed as infinite, suggesting an issue with identification of the parameters. Therefore, the 2-class model, which has the second lowest values for AIC, BIC, R^2, and log-likelihood is selected as the optimal model for this study.

Table 5-5 Comparison of information criteria for LC model selection

	2 Classes Model	3 Classes Model	4 Classes Model
Number of parameters	19	32	45
Log-likelihood (LL)	-4820.24	-4488.8	-4797.83
AIC	9678.47	9041.59	9685.66
BIC	9825.96	9254.84	10057.96
McFadden Pseudo R^2	0.2321	0.2942	0.2457
Class probability values	Class_1 (0.06) Class_2 (0.94)	Class_1 (0.07) Class_2 (0.11) Class_3 (0.81)	Class_1 (0.02) Class_2 (0.472) Class_3 (0.037) Class_4 (0.472)

Note: AIC denotes the Akaike Information Criterion; BIC denotes the Bayesian Information Criterion

5.2.3.2 Estimation of latent class model with two classes

Next, a latent class model with two classes has been estimated.

Insights into the heterogeneity recovered by the LC model can be observed by comparing the results across classes, as shown in Table 5-6. Each respondent in the sample has a non-zero probability of belonging to each of the two classes and the probability is modelled as a function of their individual-specific characteristics. The magnitudes and statistical significance of individual-specific characteristics included in the LC model are compared to understand the presence of the heterogeneity in preferences for SRD's improvement of ecological condition.

Table 5-6 Results obtained from the Latent Class model – 2 classes

	Class 1	Class 2
Utility function parameters	Parameters (standard deviation)	Parameters (standard deviation)
Status Quo	1.80*** (0.25)	-1.64*** (0.08)
Lake sturgeon (%)	0.90*** (0.19)	0.75*** (0.056)
Waterfowl population (%)	1.00*** (0.28)	0.70*** (0.067)
Muskrat abundance (%)	0.27 (0.71)	0.68*** (0.071)
Habitat in Healthy ecological condition (%)	0.24 (0.41)	0.99*** (0.083)
Annual cost	-0.99*** (0.13)	-0.37*** (0.13)
Membership equation parameters		
Male		0.10 (0.27)
Prairies		-0.21 (0.22)
People age 45 and older		0.37* (0.167)
High Income		0.26 (0.172)
High Education		0.55** (0.165)
Employed		0.04 (0.15)
Number of individuals	965	
Number of choices	5790	
Number of parameters	19	
Log-Likelihood	-4820.24	
McFadden Pseudo R-Squared	0.2321	
BIC	9825.96	

Note: ***, **, *, a - indicate statistical significance at the 0.01, 0.01, .05, 0.1 level, respectively.
More information on the definitions of the individual specific characteristics is provided in Table 4-3 'The explanatory variables used in the econometric analysis'.

Respondents with different characteristics have different preferences for the ecological attributes, but the effects are not significant. Being employed, having a higher income level, and having a higher education level, self-identifying as a male, and being older increases the probability of respondents belong to class 2 relative to class 1, but the parameters are not statistically significant, with the exception of education level and age category. In contrast, living in one of the Prairie Provinces at the time of completing the survey decreases the probability of respondents falling into class 2.

The difference in parameter estimates across the two classes suggests that respondents exhibit substantial differences in preferences for the ecological attributes. For class 1, these people prefer the status quo, all other factors remaining constant. While they prefer higher levels of the ecological attributes, the coefficients associated with muskrat and habitat in healthy ecological condition attributes are not statistically significantly different from 0. This class contains 6% of respondents. For class 2, these people are willing to pay for the improvement of the ecological condition of the SRD and move away from the status quo different from class 1, but are price sensitive. An increase in the levels of all the attributes has a positive impact on respondents' utility and all the coefficients are statistically significant. This class is the largest with 94% of the respondents.

I use the results obtained from the 2-class LC model to compute WTP measures shown in Table 5-7. Respondents with a membership in class 2 have significantly higher WTP compared to class 1 for all four ecological attributes. Moreover, MWTPs for this class are all statistically significant. Weighted average WTP estimates for this model indicate 'habitat in healthy ecological condition' as the most preferred attribute by respondents, with a WTP of $2.53 for 1% improvement in its level. On the other hand, the lowest MWTP is associated with 'muskrat abundance', for which respondents are willing to pay on average $1.76 for 1% improvement in its level. Similar insights on the most and least preferred attributes were drawn from the correlated RPL model as well. However, mean MWTP from correlated RPL model are slightly lower than the weighted average of MWTPs derived from the 2-class LC model. This comparison will be considered when selecting the model for the calculation of aggregate welfare measures, explained in the next section.

The WTP estimates obtained from the 2-class latent model clearly differ in size from the MNL model and RPL model, but similar conclusions can be drawn on how preferences of respondents vary across the ecological attributes.

Table 5-7 Marginal willingness to pay the ecological attributes using LC model

SRD ecological attributes	Class 1 MWTP	Class 2 MWTP	Weighted Average of WTP for the model
Lake sturgeon (%)	$0.91 (0.22)	$2.03 (0.15)	$1.96
Waterfowl population (%)	$1.01 (0.28)	$1.89 (0.19)	$1.84
Muskrat abundance (%)	$0.28 (0.69)	$1.85 (0.19)	$1.76
Habitat in healthy ecological condition (%)	$0.24 (0.4)	$2.68 (0.25)	$2.53

Note: Values in parentheses represent the standard error for each estimate. Weighted average of WTP for each ecological attribute is calculated as the sum of three products ($WTP_{attribute}$ for class 1 x Class 1 membership), ($WTP_{attribute}$ for class 2 x Class 2 membership).

5.3 Model selection for calculation of compensating variation and derived estimates

The results of the RPL model (both uncorrelated and correlated) and 2 – class LC model suggest that there is considerable unobserved preference heterogeneity within respondents for different ecological attributes. An examination of the log-likelihood values and the other two statistical criteria, AIC and BIC, indicated that the use of two latent classes did not provide a significant improvement in the fit over both RPL models. Only the value of R^2 exhibited an improvement from the RPL models to the LC model. Additionally, as mentioned in the previous section, the mean MWTPs estimates for all ecological attributes are slightly lower in the correlated RPL model. Therefore, I use the correlated RPL model to derive compensating variation estimates, and ultimately evaluate Canadians' valuation of a potential improvement scenario for the ecological condition of the SRD.

For this purpose, three possible 20-year restoration scenarios were created. I use the status quo levels presented in the survey as the baseline conditions. Table 5-8 shows how these restoration scenarios, labelled 'low improvement', 'medium improvement', and 'ambitious improvement' differ from each other and the baseline scenario in terms of the level of improvement for each ecological attribute. With respect to the ambitious improvement scenario, as suggested by its label, it must be noted that it is very ambitious. That is because this scenario requires the simultaneous restoration of all non-monetary attributes to the highest level possible (their conservation targets) within the 20 year period. Therefore, further research and expertise is necessary to test its feasibility within the suggested timeline.

Applying the formula of compensating variation to the linear utility function for each of the alternatives, I derive this aggregated welfare estimate for each improvement scenario (Table 5-8). Additionally, this table shows the CV estimates using an alternative log-linear-in parameters RUM specification for each alternative and applying an MNL model. The comparison is conducted to explore the effects of using different specification of the utility functions. Results of this model are presented in Appendix 5. The main difference between the two specifications of the utility functions on the CV results is found for the third improvement scenario (ambitious improvement). The CV value estimated using a log-attribute MNL model is noticeably lower, almost half of what the value generated using a linear utility specification for the correlated RPL model. It should be noted, however, that differences, although not too significant, were also found across the specifications for the other two improvement scenarios with CV estimates within the level range of the costs presented to the respondents.

Table 5-8 Compensating variation estimates for various restoration scenarios

Attribute level	Baseline Scenario	Low improvement	Medium improvement	Ambitious improvement
Lake sturgeon (% of fish conservation target)	35%	60%	60%	100%
Muskrat abundance (% out of 20 muskrat possible per hectare)	5%	No change	20%	70%
Waterfowl population (% out of breeding ducks possible)	25%	No change	50%	75%
Habitat in healthy ecological condition (% of 900,000 hectares)	45%	60%	60%	85%
CV/household/year using correlated RPL model		$118	$184	*
CV/household/year using log-attribute MNL model		$104	$151	$223

Note: * The following paragraph provides the explanation why the CV for the ambitious improvement scenario using RPL model is not provided in this table.

As the survey elicited household WTP, the resulting CV calculations are also at the household level. From the estimated CV measures above, it is noticed that the value estimated for the most ambitious improvement management scenario, which indicates the highest possible restoration levels for all SRD ecological attributes, falls outside the level range of the annual cost per household ($441/household/year). The maximum level included in the survey was $325/household/year. The probable reason for this is the linear specification of the utility function, which does not satisfy the law of diminishing[31] marginal utility.

[31] The law of diminishing marginal utility states that the marginal utility of a good or service declines as its supply increases. If this assumption holds, it would be expected that respondents are willing to pay less money to increase the level of an attribute by 1% (e.g. lake sturgeon) from 80% to 81% than what they would be willing to pay to increase its level by 1% from 20% to 21%. Because in this study, we used a linear utility function, it is implied that the amount they pay to increase the level by 1% despite the baseline level (20% or 80%) is the same, which in turn affects the CV measure.

The welfare estimates derived using both models were sensitive to scope in the sense that economic values associated with high levels of SRD improvements were higher than for low levels. It should be pointed out that the results suggest that the specification of functional form of the utility function has an effect on the welfare estimates generated. Additional specifications of the utility functions and their effects on the welfare estimates should be explored in further research, as this is not the focus of this study.

A final point worth mentioning in this regard is the alternative specific constant, denoted as status quo parameter in this thesis, and its potential implication for the welfare estimates. I explained previously that a negative sign and statistically significant value of the coefficient for the status quo parameter indicates a preference of people to move away from status quo for an improvement because they do not like the current condition of the SRD, but not related to a specific program attributes. Therefore, based on this interpretation, it might be possible that a portion of the welfare estimates is driven by the respondents that have expressed a positive willingness to pay unrelated to the presented alternative (program) attributes. In other words, the welfare estimates might be biased by the presence of yea-sayers. To investigate the magnitude of this effect, the CV estimates for RPL model were estimated again, this time excluding the status quo parameter. A difference of $34 less[32] was found for the three improvement scenarios compared to the CV estimates per household using correlated RPL model. In other words, even after excluding the SQ parameter, the CV estimates associated fully with a specific program attributes are still significant. They fall in the range of $84/household/year – 407/household/year, moving from the low improvement scenario to the ambitious one. This finding once again answers the first research objective- Canadians are willing to pay for the improvement of the ecological condition of the Delta, reflected in the improvement levels of the selected attributes.

5.4 Discussion of the main results and answering the research questions

The results across several models suggest that Canadians are willing to pay for the improvement of the delta ecological condition. Estimated annual household marginal willingness to pay values range from $1.55-$2.53 for a 1% improvement in the level of the

[32] CV/household/year: $84 – low improvement; $150 – medium improvement; $ 407 – ambitious improvement.

non-monetary attributes (lake sturgeon, muskrat abundance, habitat in healthy ecological condition, waterfowl population).

Results across all models show that increasing the level of the overall habitat in healthy ecological condition was the most desirable SRD ecosystem service for the sampled respondents as compared to the muskrat abundance, which had the lowest marginal WTP associated with it. Decision-makers can use the information on higher preferences for improving the overall habitat in healthy ecological condition when designing public policy instruments. However, it is important to point out that the higher values for habitat improvements should not necessarily imply that only this ecological endpoint should be prioritized for restoration given the lack of cost information and the interconnections between endpoints.

The results also identify important observed and unobserved heterogeneity in preferences for different ecological attributes, meaning that not everyone desires restoration equally. Being employed, having a higher income level and education level, as well as being a male and with an age falling into the category of 45 years old and above increases the willingness to pay for the improvement of the ecological condition, but the effects are not significant, with the exception of education level and age category. On the contrary, living in one of the Prairie Provinces at the time of completing the survey decreased willingness to pay for the improvement of the ecological condition of the SRD.

Alternatively, another measure of Canadians' welfare change from the restoration of the delta is provided. Compensating variation estimates show a wide range of monetary values assigned to different levels of SRD restoration from $104 - $223/household/year using the log-attribute MNL model. The welfare estimates need to be interpreted with a clear understanding of the scope of the benefits described in the survey. The low management restoration scenario is significantly different from the ambitious improvement management scenario in terms of the improvement levels of ecological indicators compared to status quo. The attribute levels specifications in the choice sets contained a built in "scope test" which showed distinct differences in preferences for different levels of change in all ecological indicators.

Since, this is the first study to estimate non-use values associated with the restoration of a river delta in Canada, no comparable Canadian valuation estimates are available, I compare our findings to non-use values reported in the literature for other ecosystem conservation in Canada. The magnitude of the estimates derived in these Canadian non-use value studies, presented in Section 3.3.2 of the Non-Market Valuation chapter, support the argument that

Canadians do put a value on ecosystems in general, including SRD, even if they perceive that they will never will directly benefit from it.

5.5 General opinions and attitudes of respondents

Respondents were also asked a series of questions regarding their opinions about general environmental issues as well the SRD conservation - related issues. At the beginning of the survey, respondents were asked how concerned they were, if at all, about the SRD ecosystem, after reading the survey information regarding the various uses of the delta and downstream impacts. Most respondents (86.5%) expressed a certain level of concern *(somewhat concerned - extremely concerned)* regarding the issues and threats SRD is facing regardless of whether they have visited or heard about the site before, as opposed to 13.5% who stated either not to be concerned or did not have an opinion.

More importantly, the majority of respondents (88% or N = 850) are willing to do more to conserve the delta, even if it costs more. This result is interesting considering that only 10% (N=92) of respondents have visited the delta before the survey. Moreover, 65% (N=625) of respondents had never heard of the delta before, highlighting the importance of the survey design to ensure they are provided full information on the good to be valued especially in the case of an unfamiliar good such as the SRD. As mentioned in the previous chapter, pretesting was used to test this aspect of the survey, in addition to other components. More detailed information on the responses to these questions is provided in table 5-9 below.

Table 5-9 A few of respondents’ perceptions of the SRD

After reading the information about the various uses of the Saskatchewan River and downstream impacts, how concerned are you, if at all, about the delta ecosystem?	Extremely concerned	Very concerned	Moderately concerned	Somewhat concerned		Not at all concerned	Don’t know	
	13.5% (130)	30.8% (297)	30.9% (298)	11.3% (109)		6.3% (31)	7.2% (70)	
Even if it costs households more money, we should do more to conserve the SRD.	Strongly Agree	Agree	Some-what Agree	Neither Agree or Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Not sure
	18.1% (175)	26.8% (259)	23.9 % (231)	14.1% (136)	6.3% (61)	3% (29)	2.6% (25)	5.1% (49)

Figure 5-1 shows responses on the importance of various benefits from natural areas in Canada. Responses are based on a ranking scale from “extremely important” to “not at all important”. Overall, most of participants consider all the listed benefits derived from natural areas as extremely important or important, compared to a small percentage that does not consider them important. In particular, a substantial percentage of respondents (35%) think that knowing that a large diverse range of plants and animals, even if they have never seen them, is an extremely important benefit provided by natural areas. This, in essence, is a non-use value, by its implied definition. Only 2% of participants think that this benefit is not important. On the other hand, the benefits of being able to eat fish and animals that have been caught in the wild or supporting tourism and provide local communities with jobs can be used to indicate use values derived by natural areas. Percentages of respondents that consider these two benefits as extremely important are smaller, 17% and 22% respectively, compared to the non-use benefits described above.

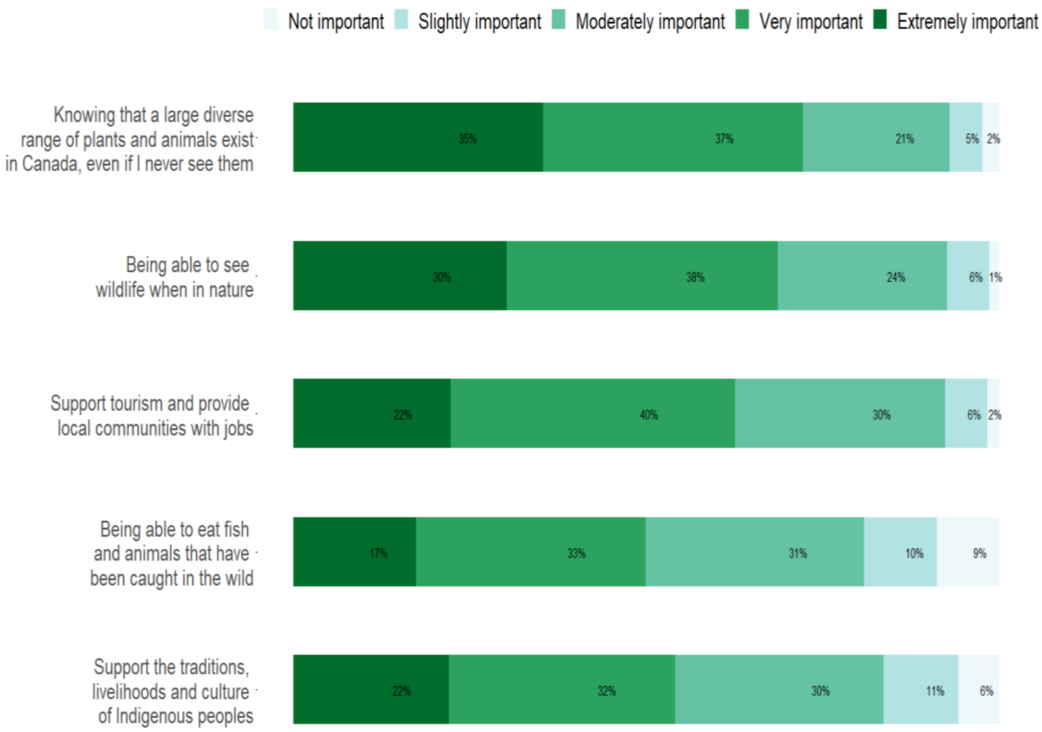


Figure 5-1 Opinions on the benefits provided by natural areas in Canada

Notes: Distribution of responses to the question “How important to you are the following benefits from natural areas in Canada?

5.5.1 Screening for respondents who exhibit any sources of potential bias

This subsection and the next one discuss the process followed to identify yea/nay-sayers and test the sensitivity of WTP estimates to the presence of these responses. At the end, it was concluded that all observations are kept in the estimation of the econometric models.

Responses to the statements discussed in this subsection for the whole sample (without creating any subsets as follows) are presented in Appendix D of the thesis.

To identify nay-sayers or protest responses, first I created a subset of only those respondents that always selected the Status Quo alternative in the choice sets. The subset included 139 respondents (approximately 14.4%). Then, I identified that portion of this subset that agreed or strongly agreed with the following statements:

(i) "I voted for the Status Quo because I am against any more taxes or government spending";

(ii) "I would not vote for the conservation programs even if there were no added costs to my household";

(iii) "I voted for the Status Quo alternative because I believe my taxes are already too high".

Approximately 3% of the sample (N=25) are identified as protest responses based on the submitted responses to the above statements.

A similar procedure was followed to identify yea-sayers. First, I created a subset of respondents that always selected the alternative with the highest cost. The subset consisted of 17 respondents (approximately 1.8%). Then, from this subset, I identified respondents that agreed or strongly agreed with the statements:

(i) "It is important to conserve the delta, no matter how much it costs";

(ii) "The added cost I am willing to pay is to protect the environment in general and not just to protect the delta".

Approximately 1.6% of the sample (N=15) are identified as warm glow based on the submitted responses to the above statements.

Table 5-10 gives more details on how respondents ranked their responses from 1 to 5 (strongly agree – strongly disagree) to the above questions. Although I analysed only responses of the respondents in the subsets described above, rather than the whole sample, percentages presented in the following table (Table 5-10) are calculated by dividing the number of respondents for each response to the total number of respondents in the survey (N=965). This gives a better idea of how influential these potential yea-sayers and protest-responses might be to biasing welfare measures.

Table 5-10 Questions employed in the SRD restoration survey used to identify protest responses and yea-sayers and results

Debriefing Questions	Likert Scale Response Options				
Responses of respondents that always selected the Status Quo alternative in the choice sets to the statements used to identify protest responses					
	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I voted for the Status Quo because I am against any more taxes or government spending.	5%	4%	4%	0.4%	0.3%
I would not vote for the conservation programs even if there were no added costs to my household.	0.1%	2%	7%	3%	2%
I voted for the Status Quo alternative because I believe my taxes are already too high.	5%	4%	4%	0.1%	0.3%
Responses of respondents that always selected the alternative with the highest cost to the statements used to identify yea-sayers					
	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
It is important to conserve the delta, no matter how much it costs.	0.8%	0.7%	0.2%	0	0
The added cost I am willing to pay is to protect the environment in general and not just to protect the delta.	0.7%	0.9%	0.1%	0	0

5.5.2 Sensitivity tests of MNL MWTP estimates to screening criteria for protest responses and yea-sayers

The sensitivity of MNL MWTP estimates to the screening criteria used to identify and eliminate protest responses and yea-sayers, as discussed in Section 5.4.1, is examined next. Two MNL models have been estimated on two subsamples, one excluding protest responses and the second one excluding yea-sayers. MWTPs are calculated for each subsample and then they are compared to the original results of the MNL model to understand the potential influence of these biases on the welfare estimates. Going from the MWTP values for the full sample to the subset in which yea-sayers are excluded, I notice a slight decrease of around 3% - 9% in the estimates, which shows the effect of yea-sayers in biasing WTP measures upward (Table 5-11[33]). In contrast, MWTP estimates of the subset in which protest-responses

[33] Complete results of MNL models with yea-sayers and protest responses excluded are provided in Appendix B.

are excluded are higher compared to the full sample estimates (increase from 6% - 20%), indicating the effect of nay-sayers in biasing the WTP estimates downward.

Table 5-11 MWTP under screening criteria of removing yea-sayers and protest responses

MWTP estimates	Full Sample (standard errors)	Yea-sayers excluded (standard errors)	Protest-responses excluded (standard errors)
Lake sturgeon (%)	$1.84 (0.18)	$1.75 (0.16)	$2.23 (0.25)
Waterfowl population (%)	$1.74 (0.19)	$1.62 (0.17)	$1.93 (0.25)
Muskrat abundance (%)	$1.63 (0.21)	$1.47 (0.18)	$1.74 (0.25)
Habitat in healthy ecological condition (%)	$2.32 (0.26)	$2.25 (0.24)	$2.68 (0.35)

The results in Table 5-11 reveal little difference in the MWTP for ecological attributes improvement when I exclude either protest-responses or yea-sayers. Removing protest-responses has a slightly greater influence on the MWTP estimates than removing yea-sayers. However, the range within the values vary is such that these two counteracting effects seem to offset each other. Thus, it makes sense to say that the MWTP estimates for a subset in which both yea-sayers and nay-sayers were to be excluded would be close in magnitude to the full sample MWTPs. Because the sensitivity of the MNL results for the full sample to the potential presence of yea-sayers and protest responses does not seem concerning, all observations are kept in the estimation of the econometric models presented in this chapter.

5.5.3 Some of the factors affecting choices of respondents

A series of debriefing 5-point Likert type questions were incorporated in the survey to understand factors, other than the attribute levels specific to alternatives in the choice set, that may have influenced respondent choices. Respondents were asked to indicate their degree of agreement with certain statements such as: a) how likely they think it is for the government to take into account their vote and that of the other respondents to this study, when deciding whether or not to implement the SRD future scenarios; b) how effective they think the presented alternatives will be at conserving the delta over the next 20 years, or if those alternatives are feasible to begin with.

Detailed results on the responses for these two groups are presented in Table 5-12. Presented percentages are based on the entire sample (N=965 respondents).

Table 5-12 Highlights of respondent perceptions on importance of their vote in decision making and feasibility of restoration scenarios

Respondents that selected either Alternative A or B in the choice sets at least once and answered the question *"When the federal and provincial governments decide whether or not to implement the Saskatchewan River Delta future scenarios you just voted on, how likely do you think it is that the governments will take into account your vote and that of the other respondents to this study in its decision-making?"*	
Very likely	3%
Likely	9%
Somewhat likely	30%
Somewhat unlikely	22%
Unlikely	12%
Very unlikely	8%
Respondents always selected the Status Quo alternative and answered the question *"If one of the alternative scenarios is implemented, how effective do you think it will be at conserving the delta over the next 20 years?"*	
Extremely effective	0.5%
Very effective	1.1%
Moderately effective	7%
Slightly effective	3%
Not effective at all	2%
Respondents always selected the Status Quo alternative and answered the question *"I do not believe that the alternative conservation scenarios are actually feasible."*	
Strongly Agree	2%
Agree	3%
Neither Agree or Disagree	8%
Disagree	0.5%
Strongly disagree	0.7%

Based on the submitted responses, out of 85% (N=823) of the respondents that selected one of the restoration alternatives in the choice sets at least once, 15% expressed that it is very likely or likely for their vote not to be taken into consideration by the government in its decision-making process. On the other hand, around 14% (N=139) of the respondents always selected the status quo alternative for all six choice sets. Out of this percentage, 17% thought that presented restoration alternatives would not be effective at all at conserving the delta over the next 20 years while 34% of this subsample did not perceive the restoration alternatives as actually feasible.

The results provided in the next two paragraphs inform about the influence of the design of the web survey on the quality and honesty of responses. Respondents' responses indicate that the survey is well-designed to provide accurate and unbiased data.

Considering the low level of respondents' familiarity with the SRD, it is of interest to understand if information provided helped to make an informed choice and if the information was easy to understand. Responses indicate that the majority of respondents (60%) felt they had enough information to make an informed choice while 30% did not have a clear opinion on the *statement (these respondents chose 'Neither agree or disagree')*. 89% of respondents found the information easy to understand. These percentages are good indicators of the validity of the survey instrument- the extent of the questions to measure what they are intended to measure.

Additionally, I sought to understand if information is presented to respondents in such a way that it influenced their responses, risking non-truthful preferences. Overall, most respondents (70%) stated that the information was presented in such a way that it let them make up their own mind. Detailed percentages are provided in Table 5-13.

Table 5-13 Feedback from respondents on the potential of providing information to influence their responses

	Percentage	
Tried to push you to choose the Status Quo option	Tried to push you to choose the Alternative A or B option	Let me make up my own mind
8%	22%	70%

5.5.4 Effects of COVID-19 pandemic on reported welfare estimates

Data collection in this study was done during the period of the pandemic, which raises questions on what impact the pandemic has on the results of the study. To understand the potential effect of undertaking the data collection during the coronavirus (COVID-19) pandemic, the survey asked the respondents if their priority of spending money has changed with the COVID-19 pandemic (answers: (1) strongly agree – (5) strongly disagree) and if their household received income support or lost their employment due to COVID-19 (answers: Yes, No). Although the included questions were an imperfect measurement, responses suggest that the pandemic affected respondents' priorities of spending money. Indeed, 51% of the sample reported that COVID-19 has changed their priority of spending money and 23% of the sample either lost employment or received income support due to COVID-19. This might indicate that derived welfare measures for the improvement of the SRD are lower than what they would have been if the survey was conducted prior to the pandemic, but no clear conclusion can be drawn at this point.

There is no consensus on what impact COVID has had on environmental preferences. The results of a 2021 study (Hynes et al., 2021) on the stability of environmental preferences and WTP across three countries, Canada, Norway, and Scotland, following the global pandemic of COVID-19, suggested that in general the mean preferences were stable, contrary to authors' priori expectation that marginal WTPs for the environmental attribute would decline due to the heightened uncertainty and concern for future income caused by the pandemic. Marco et. al (2020) suggest that one possible reason why environmental preferences stay relatively stable could be people's awareness that the risk of pandemics may be increased by the negative human impact on natural environment. Additionally, it may be possible for the any potential income effect caused by COVID-19 to cancel out due to the potential shift in people's perception of the vulnerability of nature and the increasing perceived value of ecosystem services, which might have happened because of the long lockdown experience (Hynes et al., 2021).

Chapter 6: SUMMARY AND CONCLUSION

6.1 Introduction

The aim of this thesis was to understand whether and to what extent Canadians are willing to pay for the improvement of the ecological condition of the Saskatchewan River Delta (SRD). As such, the study had two research objectives. First, estimate the amount Canadians are willing to pay, and as a result, quantify the perceived welfare effects of improvements to the SRD. Second, understand preference heterogeneities with respect to location of residence, age, income levels and other socio-economic characteristics.

The values obtained in this study are almost exclusively non-use values, due to, but not limited to, the quota-sampling technique process of selecting the final sample. The percentage of the Saskatchewan residents who might indicate use values when selecting the presented alternatives is small compared to the rest of the sample. Non-use values associated with the SRD improvement of ecological condition are measured in monetary units of individuals' willingness to pay, which is associated with a change in the provision level of specific ecological indicators, lake sturgeon, muskrat abundance, waterfowl population, and habitat in healthy ecological condition. A multi-stage process was used to determine which environmental outcomes should be used to depict the improvement of the ecological condition of the SRD under alternative policy development scenarios, to ensure the selected attributes are measurable, interpretable, applicable, and comprehensive.

The purpose of this chapter is to provide a discussion of potential implications of the study as well as present potential limitations and recommendations for future research.

6.1.1 Potential uses of the study results

The main outcomes of this research are novel estimates of the non-use economic benefits associated with restoring the Saskatchewan River Delta.

The findings of this study have significant policy implications. Respondents of the survey are clearly willing to pay for the restoration of the Saskatchewan River Delta, and the non-use values derived from this ecosystem and its services are important. The study not only provides credible economic values for the restoration of SRD in particular but also suggests that there can be a level of confidence that valid non-use values for river deltas in Canada do, in fact, exist and can be quantified.

Explained preference heterogeneity with respect to a few of socio-demographic characteristics provides insight into the social demand for the Delta restoration. The results indicate that Canadians will receive different benefits from any restoration program, based on their income level, age category, education level, employment status, gender, or province of residence. Decision-makers and public managers can then use this knowledge and information on the sources of heterogeneity to improve SRD restoration. *Ex-ante* assessment of preference heterogeneity supports them develop restoration measures and initiatives that are more socially acceptable and better suit preferences of individuals by age category, income level and so forth. Ultimately, these measures are more likely to receive greater support in terms of the economic instruments (such as the annual tax at the household level used in this study) applied for their implementation, operational, and maintenance costs.

When it comes to predicting the exact restoration trajectory of the SRD, there is a lot of uncertainty. In addition to existing deterioration upstream threats, climate change impacts and future development projects (irrigation, industrial, urban, etc.) will also affect the ecological condition of the delta, thus adding to the uncertainty around which restoration scenario is more likely to occur. Making use of the DCE approach, this study can inform the benefit estimates for a variety of future scenarios depending on what occurs in the future. Welfare estimates associated with the restoration of SRD can be used as a starting point in more advanced cost-benefit analyses and assist decision-makers to soundly weigh various policy options and incorporate the most efficient and/or cost-effective measures to restore, sustain and protect natural systems and maintain environmental quality at the earliest stages of planning. In this study, benefits are reflected in the WTP of improving the provision levels of the selected attributes and the compensating variation for improving the SRD ecological condition.

From a policy perspective, it is important to acknowledge that the design and implementation of any restoration initiative or management program requires accurate information on both benefits and costs side. While this study provides the benefits associated with SRD restoration, information on the associated costs is equally important. Costs need to be valued according to the WTP for the use of resources, directly or indirectly through the upstream activities, with the SRD, and therefore, reflect the best alternative foregone or opportunity cost. A wide range of stakeholders across the three Prairie Provinces who benefit from the economic activities (various uses of water) upstream the Delta will be affected at various extent if any SRD restoration scenario gets to be implemented. Future projections and increasing government focus and economic support of hydropower and irrigation projects is expected to lead to higher economic value of the Saskatchewan River water to the province residents and hence to higher opportunity cost of allocating water for the Delta restoration. This is a consideration that must be included in any benefit-cost analysis when assessing the trade-offs around various restoration measures, how likely these interventions are to happen, and the associated challenges.

To illustrate the importance of incorporating both components in the decision-making (costs in addition to benefits), the case of the E.B. Campbell dam can be used to provide a proxy for the cost of changing water release quantities and timing. Because the water held by the dam is used to generate electricity, any release schedule that is not based on maximizing electricity generation will cost Saskatchewan Power Corporation (SaskPower) in foregone electricity sales. The estimated cost of E.B. Campbell dam spilling 20 m^3/s of water is $5,333/day, which would total just under $2 million/year if the spillway was left open year round. Although, this value requires adjustment and further analysis on the operation scenarios of the dam, for now it can be used as a reasonable figure to provide insight into the order of magnitude of cost for some sort of river flow restoration (Tim Jardine, personal communication, July 11, 2022). This cost in electricity revenue needs to be compared to benefits of Delta restoration as a result of such change in water release quantities and timing to better weigh policy options and understand trade-offs of actions.

Moreover, since there is a limited literature of river delta restoration with study sites in Canada, the results of this study can be transferred to other restoration projects in similar river delta ecosystems implementing the benefit transfer method. Particularly, the extrapolation of this study results is considered beneficial in situations where the collection of primary data may not be time and cost-effective (Bergstrom et al., 2017). However, there are a few issues and a substantial degree of uncertainty that need to be taken into consideration for benefits transfer applications. Sensitivity of people’s preferences to changes in the context in which they were elicited, relevance of the ecological attributes presented here in describing the other river delta ecological condition, and other aspects of the similarity between the study sites are important factors that affect the validity of the extrapolated results.

6.1.2 Research limitations

A few factors affect conclusions drawn from this study. One main limitation is that the information collected through stated preference approaches may suffer from many well-known biases. In the survey I employed several strategies to mitigate against hypothetical bias and strategic behaviour, such as format text emphasizing the importance of the respondents' answers to policy makers, reminders about the respondents' budget constraints, to name a few. After the valuation questions, respondents were asked a series of debriefing questions to gain more insight on the factors and motivations for each response a well as identify potential yea-sayers and protest responses. One complication is that the variables that measure consequentiality and certainty of responses are most likely endogenously determined with the respondents' choices. This makes it challenging to use these variables to control for potential hypothetical bias.

Determination of the socially efficient level of SRD restoration would be an important extension of the results obtained in this thesis. That requires a cost-benefit analysis. The results of this study can be used as an input in this process to measure the broader benefits from different conservation opportunities of the SRD. However, it is also necessary to collect and estimate the cost data, for such determination.

Another factor that affects the results is the use of the repetition of choice tasks. In this survey, each respondent is assigned six different random choice sets to value the SRD. This raises two issues. First, does advanced awareness of multiple tasks influence stated preferences from the outset. Second, does the process of working through a series of choice tasks influence stated preferences leading to choice outcomes that are dependent on the order in which a question is answered.

6.1.3 Suggestions for future research

One area for future research is building upon findings of this research and further explore the possible motivators of both advanced awareness and ordering effects and be able to understand if strategic behaviour is exhibited or if there is evidence of behavioural explanations such as learning effects or response heuristics.

This study uses only CE elicitation technique to derive the welfare estimates. Therefore, at this point no conclusions can be drawn from this study regarding the differences (if any) between the welfare estimates generated using this technique compared to the other SP technique. That requires a parallel econometric analysis of the results generated using the contingent valuation survey version, which presents an opportunity for further complementary research. Also, the monetary values attributed to the SRD, in this case, can be studied from the perspective of willingness to accept (WTA) and analyze if there is any disparity between a person's WTP and WTA. This will help assess whether WTA can be categorized as useful welfare measure to WTP in public good framing, as it is suggested in recent experimental literature (Lloyd-Smith & Adamowicz, 2018). All these data has been collected from the other three survey versions mentioned earlier in the thesis.

It is recommended that further valuation work of additional ecological indicators, such as carbon potential be undertaken, if the values from this research are going to be used for the setting of incentive payments in future restoration programs. In the context of this research, the marginal willingness to pay for each of the attributes represent the level of support for programs that would improve the ecological condition of the SRD through the restoration/improvement of the attributes in the choice set alternatives, which have been selected to be only four. Thus, it is important to note that these values are not representative of the total value of ecosystem services provided by the SRD.

Additionally, discussion presented in section 2.3.3 of the thesis around the challenges associated with estimating costs of management actions to improve the ecological condition of the delta presents an opportunity for future research.

BIBLIOGRAPHY

Abirhire, O., Davies, J.-M., Imtiazy, N., Hunter, K., Emmons, S., Beadle, J., & Hudson, J. (2022). Response of phytoplankton community composition to physicochemical and meteorological factors under different hydrological conditions in Lake Diefenbaker.

Abu, R. (2017). Knowledge, Use, and Change in the Saskatchewan River Delta: Assessing the Changing Livelihoods of Cumberland House Métis and Cree Nation. University of Saskatchewan .

Abu, R., & Reed, M. G. (2018). Adaptation through bricolage: Indigenous responses to long-term social-ecological change in the Saskatchewan River Delta, Canada. Canadian Geographer, 62(4), 437–451. https://doi.org/10.1111/cag.12469

Abu, R., Reed, M. G., & Jardine, T. (2020). Using two-eyed seeing to bridge Western science and Indigenous knowledge systems and understand long-term change in the Saskatchewan River Delta, Canada. International Journal of Water Resources Development, 36(5), 757–776. https://doi.org/10.1080/07900627.2018.1558050

Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998a). Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. In American Journal of Agricultural Economics (Vol. 80, Issue 1).

Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998b). Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. American Journal of Agricultural Economics, 80(1), 64–75. https://doi.org/10.2307/3180269

Adamowicz, W., Louviere, J., & Swait, J. (1998). Introduction to Attribute-Based Stated Choice Methods. https://www.researchgate.net/publication/242494897_Introduction_to_Attribute-Based_Stated_Choice_Methods

Adamowicz, W., Louviere, J., & Williams, M. (1993). Combining revealed and stated preference methods for valuing environmental amenities. Journal of Environmental Economics and Management.

Adamowicz, W., Swait, J., Boxall, P., Louviere, J., & Williams, M. (1997). Perceptions versus Objective Measures of Environmental Quality in Combined Revealed and

Stated Preference Models of Environmental Valuation*. In Journal of Environmental Economics and Management (Vol. 32).

Agimass, F., Lundhede, T., Panduro, T. E., & Jacobsen, J. B. (2018). The choice of forest site for recreation: A revealed preference analysis using spatial data. Ecosystem Services, 31, 445–454. https://doi.org/10.1016/J.ECOSER.2017.11.016

Ahn, S., De Steiguer, J. E., Palmquist, R. B., & Holmes, T. P. (2000). Economic Analysis of the Potential Impact of Climate Change on Recreational Trout Fishing in the Southern Appalachian Mountains: An Application of a Nested Multinomial Logit Model. Climatic Change 2000 45:3, 45(3), 493–509. https://doi.org/10.1023/A:1005511627247

Alvarez, S., Larkin, S. L., Whitehead, J. C., & Haab, T. (2014). A revealed preference approach to valuing non-market recreational fishing losses from the Deepwater Horizon oil spill. Journal of Environmental Management, 145, 199–209. https://doi.org/10.1016/J.JENVMAN.2014.06.031

Andreoni, J. (1989). Giving with Impure Altruism: Applications to Charity and Ricardian Equivalence on JSTOR. Journal of Political Economy, 97(6), 1447–1458. https://www.jstor.org/stable/1833247

Andrews, E. J., Reed, M. G., Jardine, T., & Steelman, T. A. (2018). Damming Knowledge Flows: POWER as a Constraint on Knowledge Pluralism in River Flow Decision-making in the Saskatchewan River Delta. Society & Natural Resources, 31(8), 892–907. https://doi.org/10.1080/08941920.2018.1451582

Anhorn, C. (n.d.). Nominating the Saskatchewan River Delta for a Ramsar Designation - CPAWS Saskatchewan. CPAWS. Retrieved May 27, 2021, from https://cpaws-sask.org/nominating-the-saskatchewan-river-delta-for-a-ramsar-designation/

Arrow, K., Leamer, E., Schuman, H., Solow, R., Portney, P. R., Leamer, E. E., & Radner, R. (1993). Report of the NOAA panel on Contingent Valuation Report of the NOAA Panel on Contingent Valuation Report of the NOAA Panel on Contingent Valuation. https://www.researchgate.net/publication/235737401

Asante, C. K., Jardine, T., Van Wilgenburg, S. L., & Hobson, K. A. (2017). Tracing origins of waterfowl using the Saskatchewan River Delta: Incorporating stable isotope approaches in continent-wide waterfowl management and conservation. Condor, 119(2). https://doi.org/10.1650/CONDOR-16-179.1

Baker, B., & Ruting, R. (2014). Environmental Policy Analysis: A Guide to Non-Market Valuation Productivity Commission Staff Working Paper. www.pc.gov.au.

Bank of Canada. (n.d.). Inflation Calculator - Bank of Canada. (n.d.). Retrieved August 1, 2022, from https://www.bankofcanada.ca/rates/related/inflation-calculator/

Baschuk, M. S. (2010). Effects of Water-level Management on the Abundance and Habitat Use of Waterfowl and Marsh Birds in the Saskatchewan River Delta, Manitoba, Canada.

Baschuk, M. S., Ervin, M. D., Clark, W. R., Armstrong, L. M., Wrubleski, D. A., & Goldsborough, G. L. (2012). Using Satellite Imagery to Assess Macrophyte Response to Water-level Manipulations in the Saskatchewan River Delta, Manitoba. Wetlands, 32(6), 1091–1102. https://doi.org/10.1007/s13157-012-0339-z

Bateman, I., Carson, R., Hanemann, M., Hanley, N., Hett, T., Jones, M. J., Loomes, L., & Loomes, G. (2002). Economic valuation with stated preference techniques : a manual. Edward Elgar Publishing.

Bergkamp, G., McCartney, M., Dugan, P., McNeely, J. A., & Acreman, M. (2000). Dams, ecosystem functions and environmental restoration : final version | IUCN Library System. WCD Thematic Review Environmental Issues. https://portals.iucn.org/library/node/11816

Bergstrom, J. C., Loomis, J. B., & Russell, R. B. (2016). Economic valuation of river restoration: An analysis of the valuation literature and its uses in decision-making. https://doi.org/10.1016/j.wre.2016.12.001

Bertram, C., & Rehdanz, K. (2013). On the environmental effectiveness of the EU Marine Strategy Framework Directive. Marine Policy, 38, 25–40. https://doi.org/10.1016/J.MARPOL.2012.05.016

Bishop, R. C., & Boyle, K. J. (2018). Reliability and Validity in Nonmarket Valuation. Environmental and Resource Economics 2018 72:2, 72(2), 559–582. https://doi.org/10.1007/S10640-017-0215-7

Bishop, R. C., Boyle, K. J., Carson, R. T., Chapman, D., Hanemann, W. M., Kanninen, B., Kopp, R. J., Krosnick, J. A., List, J., Meade, N., Paterson, R., Presser, S., Smith, V. K., Tourangeau, R., Welsh, M., Wooldridge, J. M., DeBell, M., Donovan, C., Konopka, M., & Scherer, N. (2016). Putting a value on injuries to natural assets: The BP oil spill. Environmental Evconomics. https://doi.org/10.1126/science.aam8124

Bishop, R. C., Boyle, K., & Welsh, M. P. (1987). Toward Total Economic Valuation of Great Lakes Fishery Resources. Transactions of The American Fisheries Society, 116, 339–345.

Blamey, R. K., Bennett, J. W., & Morrison, M. D. (1999). Yea-saying in contingent valuation surveys. Land Economics, 75(1), 126–141. https://doi.org/10.2307/3146997

Blamey, R. K., Bennett, J. W., Louviere, J. J., Morrison, M. D., & Rolfe, J. C. (2002). Attribute Causality in Environmental Choice Modelling. Environmental and Resource Economics 2002 23:2, 23(2), 167–186. https://doi.org/10.1023/A:1021202425295

Bockstael, N. E., & McConnell, K. E. (1980). Calculating equivalent and compensating variation for natural resource facilities. Land Economics, 56(1), 56–63. https://doi.org/10.2307/3145829

Bockstael, N. E., McConnell, K. E., & Strand, I. E. (1989). Measuring the Benefits of Improvements in Water Quality: The Chesapeake Bay on JSTOR. Marine Resource Economics, 6(1), 1–18. https://www.jstor.org/stable/42628999

Bouwes, N. W., & Schneider, R. (1979). Procedures in Estimating Benefits of Water Quality Change. American Journal of Agricultural Economics, 61(3), 535–539. https://doi.org/10.2307/1239442

Boxall, P. C. (1995). The Economic Value of Lottery-rationed Recreational Hunting. Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie, 43(1), 119–131. https://doi.org/10.1111/J.1744-7976.1995.TB00111.X

Boxall, P. C., & Adamowicz, W. L. (2002). Understanding Heterogeneous Preferences in Random Utility Models: A Latent Class Approach. Environmental and Resource Economics 2002 23:4, 23(4), 421–446. https://doi.org/10.1023/A:1021351721619

Boxall, P. C., Adamowicz, W. L., Olar, M., West, G. E., & Cantin, G. (2012). Analysis of the economic benefits associated with the recovery of threatened marine mammal species in the Canadian St. Lawrence Estuary. Marine Policy, 36(1), 189–197. https://doi.org/10.1016/J.MARPOL.2011.05.003

Boxall, P., Adamowicz, W. L., & Moon, A. (2009). Complexity in choice experiments: choice of the status quo alternative and implications for welfare measurement*. Australian Journal of Agricultural and Resource Economics, 53(4), 503–519. https://doi.org/10.1111/J.1467-8489.2009.00469.X

Boyle, K., Champ, P. A., & Brown, T. T. (2003). Introduction to Revealed Preference Methods. In A Primer on Nonmarket Valuation. The economics of Non-Market Goods and Resources (Vol. 3, pp. 259–267). Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0826-6_8

Brauman, K. A., Daily, G. C., Ka'eo Duarte, T., & Mooney, H. A. (2007). The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. Annual Review of Environment and Resources. https://doi.org/10.1146/annurev.energy.32.031306.102758

Breffle, W. S., & Morey, E. R. (2015). Investigating Preference Heterogeneity in a Repeated Discrete-Choice Recreation Demand Model of Atlantic Salmon Fishing. The University of Chicago Press Journals, 15(1), 1–20. https://doi.org/10.1086/MRE.15.1.42629285

Bruneau, J., Martz, L. W., & Rolfe, J. T. (2007). Climate Change and Water: SSRB (South Saskatchewan River Basin) Final Technical. https://doi.org/10.13140/RG.2.2.12833.76646

Buckell, J., Buchanan, J., Wordworth, S., Becker, F., Morrel, L., Kaur, A., & Abel, L. (2020). Hypothetical bias . Catalog of Bias. https://catalogofbias.org/biases/hypothetical-bias/

Campbell, D., Boeri, M., Doherty, E., & George Hutchinson, W. (2015). Learning, fatigue and preference formation in discrete choice experiments. Journal of Economic Behavior & Organization, 119, 345–363. https://doi.org/10.1016/J.JEBO.2015.08.018

Canadian Parks and Wilderness Society. (2021). Canadian Parks and Wilderness Society celebrates declaration of Indigenous-led protection of the Saskatchewan River Delta by Cumberland House Cree Nation - CPAWS. https://cpaws.org/canadian-parks-and-wilderness-society-celebrates-declaration-of-indigenous-led-protection-of-the-saskatchewan-river-delta-by-cumberland-house-cree-nation/

Canadian Parks and Wilderness Society. (n.d.). Saskatchewan Chapter. Retrieved May 19, 2021, from https://cpaws-sask.org/what-we-do/saskatchewan-river-delta/

Carlsson, F., Frykblom, P., & Liljenstolpe, C. (2003). Valuing wetland attributes: an application of choice experiments. Ecological Economics, 47(1), 95–103. https://doi.org/10.1016/J.ECOLECON.2002.09.003

Carson, R. T. (2000). Contingent Valuation: A User's Guide. Environmental Science and Technology, 34(8), 1413–1418. https://doi.org/10.1021/ES990728J

Carson, R. T. (2012). Contingent Valuation: A Practical. Journal of Economic Perspectives , 26(4), 27–42. https://doi.org/10.1257/jep.26.4.27

Carson, R. T., & Groves, T. (2007). Incentive and informational properties of preference questions. Environmental Resource Economics, 181–210.

Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. (2003). Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill. Environmental and Resource Economics, 25, 257–286.

Carson, R. T., Mitchell, R. C., Michael H'anemann, W., Kopp, R. J., Presser, S., & Ruud, P. A. (1992). Valuation study of lost passive use values resulting from the Exxon Valdez oil spill.

Carson, R., & Navarro, P. (1988). Fundamental Issues in Natural Resource Damage Assessment. Nat. Resources J, 28.

Casey, A. (2013). Hope for the Saskatchewan River Delta? | Canadian Geographic. Canadian Geographic. https://www.canadiangeographic.ca/article/hope-saskatchewan-river-delta

Cavanaugh, J. E., & Neath, A. A. (2019). The Akaike information criterion: Background, derivation, properties, application, interpretation, and refinements. Wiley Interdisciplinary Reviews: Computational Statistics, 11(3), e1460. https://doi.org/10.1002/WICS.1460

Champ, P. A., Boyle, K. J., & Brown, T. C. (2003). The Economics of Non-Market Goods and Resources A Primer on Nonmarket Valuation (I. J. Bateman (Ed.); Second, Vol. 13). Springer. http://www.springer.com/series/5919

ChoiceMetrics Pty Ltd. (2018). Ngene 1.2 User Manual & Reference Guide. http://www.choice-metrics.com/NgeneManual120.pdf

Colombo, S., Hanley, N., Louviere, J., Colombo, S., Hanley, N., & Louviere, J. (2009). Modeling preference heterogeneity in stated choice data: an analysis for public goods generated by agriculture. Agricultural Economics, 40(3), 307–322. https://doi.org/10.1111/J.1574-0862.2009.00377.X

Crocker, L. M., & Algina, J. (1986). Introduction to classical and modern test theory. Holt, Rinehart, and Winston.

Czajkowski, M., & Hanley, N. (2009). Using Labels to Investigate Scope Effects in Stated Preference Methods. Environmental and Resource Economics 2009 44:4, 44(4), 521–535. https://doi.org/10.1007/S10640-009-9299-Z

Czajkowski, M., Giergiczny, M., & Greene, W. H. (2014). Learning and Fatigue Effects Revisited: Investigating the Effects of Accounting for Unobservable Preference and

Scale Heterogeneity. Land Economics, 90(2), 324–351. https://doi.org/10.3368/LE.90.2.324

Dias, V., & Belcher, K. (2015). Value and provision of ecosystem services from prairie wetlands: A choice experiment approach. Ecosystem Services, 15, 35–44. https://doi.org/10.1016/J.ECOSER.2015.07.004

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2009). Internet, main and mixed-mode surveys: the tailored design method (3rd ed.). Wiley & Sons.

Do, T. N., & Bennett, J. (2009). Estimating wetland biodiversity values: a choice modelling application in Vietnam's Mekong River Delta. Environment and Development Economics , 14(2), 163–186. https://www-jstor-org.cyber.usask.ca/stable/pdf/44379030.pdf?refreqid=excelsior%3A418807ebe77f1c679eb25ac0b71d18ce

Domanski, A. (2019). Lower Snake River dams economic tradeoffs of removal. https://static1.squarespace.com/static/597fb96acd39c34098e8d423/t/5d41bbf522405f0001c67068/1564589261882/LSRD_Economic_Tradeoffs_Report.pdf

Ducks Unlimited Canada. (2019). Rebuilding the South Reader Outlet—Ducks Unlimited Canada. https://www.ducks.ca/stories/wetlands/rebuilding-the-south-reader-outlet/

Dupont, D. P. (2003a). CVM Embedding Effects When There Are Active, Potentially Active and Passive Users of Environmental Goods. Environmental and Resource Economics, 25(3), 319–341. https://doi.org/10.1023/A:1024446110640

Dupont, D. P. (2003b). CVM Embedding Effects When There Are Active, Potentially Active and Passive Users of Environmental Goods. Environmental and Resource Economics 2003 25:3, 25(3), 319–341. https://doi.org/10.1023/A:1024446110640

Dupont, D., Renzetti, S., & Bruce, J. (2010). Economic Value of Protecting the Great Lakes: Literature Review Report. https://www-deslibris-ca.cyber.usask.ca/ID/235122

Earnscliffe Strategies. (2017). National Conservation Survey Research Report.

Ervin, M. (2011). Population characteristics and habitat selection of muskrats (Ondatra zibethicus) in response to water level management at the Summerberry Marsh Complex, The Pas. Iowa State University.

Finlayson, M., Lévêque, C., Randy Milton, G., Peterson, G., Pritchard, D., Ratner, B. D., Reid, W. V, Revenga, C., Rivera, M., Schutyser, F., Siebentritt, M., Stuip, M., Tharme, R., Mooney, H. A., Cropper, A., Capistrano, D., Carpenter, S. R., Chopra, K., Dasgupta, P., … Watson, R. T. (2005). A Report of the Millennium Ecosystem Assessment Contributing Authors, and Sub-global Coordinators Review Editors: José Sarukhán and Anne Whyte (Co-chairs) and MA Board of Review Editors The Cropper Foundation, Trinidad and Tobago.

Fischhoff, B., & Furby, L. (1988). Measuring values: A conceptual framework for interpreting transactions with special reference to contingent valuation of visibility. Journal of Risk and Uncertainty 1988 1:2, 1(2), 147–184. https://doi.org/10.1007/BF00056166

Freeman III, A. M., Herriges, J. A., & Kling, C. L. (2014a). The Measurement of Environmental and Resource Values (Third Edition). RFF PRESS Resources for the Future .

Freeman III, A. M., Herriges, J. A., & Kling, C. L. (2014b). Welfare Measures: Theoretical basis for empirical assessment. In The measurement of environmental and resource values Theory and Methods (pp. 81–126).

García-Llorente, M., Martín-López, B., & Montes, C. (2011). Exploring the motivations of protesters in contingent valuation: Insights for conservation policies. Environmental Science & Policy, 14(1), 76–88. https://doi.org/10.1016/J.ENVSCI.2010.11.004

Government of Canada. (n.d.). Canada Target 1 Challenge - Canada.ca. Retrieved April 19, 2021, from https://www.canada.ca/en/environment-climate-change/services/nature-legacy/canada-target-one-challenge.html

Government of Canada. (n.d.). Environmental funding programs - Canada.ca. (n.d.). Retrieved March 3, 2022, from https://www.canada.ca/en/environment-climate-change/services/environmental-funding/programs.html

Government of Canada-Species at risk public registry. (2021). Progress Report on Steps Taken for Protection of Critical Habitat for Species at Risk in Canada. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/critical-habitat-reports/dec-2021.html

Grafton, R. Q., Adamowicz, W., Dupont, D., Nelson, H., Hill, R. J., & Renzetti, S. (2004). The economics of the environment and natural resources. Blackwell Pub.

Graham, R., Mansfield, C., Houtven, G. Van, Hendershott, A., Chen, P., Porter, J., Nourani, V., & Kilambi, V. (2012). Klamath River Basin Restoration Nonuse Value Survey Final Report Prepared for Klamath River Basin Restoration Nonuse Value Survey Final Report.

Gregory, R. J. (2004). Psychological testing : history, principles, and applications. Pearson/A and B.

Haab, T. C., & McConnell, K. E. (2002). Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation. Edward Elgar.

Haener, M. K., & Adamowicz, W. L. (2011). Regional forest resource accounting: a northern Alberta case study. Https://Doi.Org/10.1139/X99-213, 30(2), 264–273. https://doi.org/10.1139/X99-213

Hanemann, W. M. (1984). Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses. American Journal of Agricultural Economics, 66(3), 332–341. https://doi.org/10.2307/1240800

Hanemann, W. M. (1991). Willingness to Pay and Willingness to Accept: How Much Can They Differ? The American Economic Review, 81(3), 635–647. https://www.jstor.org/stable/2006525

Hanley, N., & Barbier, E. (2009). Cost-benefit Analysis and Environmental Policy. In Pricing nature: cost-benefit analysis and environmental policy (Issue 2009). Edward Elgar Publishing. https://books.google.com/books/about/Pricing_Nature.html?id=Ojg9u-fS9dAC

Hanley, N., Adamowicz, W., & Wright, R. E. (2005). Price vector effects in choice experiments: an empirical test. Resource and Energy Economics, 27(3), 227–234. https://doi.org/10.1016/J.RESENEECO.2004.11.001

Hanley, N., Bell, D., & Alvarez-Farizo, B. (2003). Valuing the Benefits of Coastal Water Quality Improvements Using Contingent and Real Behaviour. Environmental and Resource Economics 2003 24:3, 24(3), 273–285. https://doi.org/10.1023/A:1022904706306

Hanley, N., MacMillan, D. C., Wright, R. E., Bullock, C., Simpson, I., Parsisson, D., & Crabtree, B. (1998). Contingent valuation versus choice experiments: Estimating the benefits of environmentally sensitive areas in Scotland. Journal of Agricultural Economics , 49(1), 1–15. https://doi.org/10.1111/j.1477-9552.1998.tb01248.x

Harpman, D. A., Welsh, M. P., & Bishop, R. C. (1994). NONUSE ECONOMIC VALUE: EMERGING POLICY ANALYSIS TOOL.

Hassanzadeh, E. (2019). Trade-Offs between Human and Environment_ Challenges for Regional Water Management under Changing Conditions _ Enhanced Reader. Water, 11(9). https://doi.org/. https://doi.org/10.3390/w11091773

Hassanzadeh, E., Elshorbagy, A., Nazemi, A., Jardine, T., Wheater, H., & Lindenschmidt, K. E. (2017). The ecohydrological vulnerability of a large inland delta to changing regional streamflows and upstream irrigation expansion. Ecohydrology, 10(4), e1824. https://doi.org/10.1002/ECO.1824

Hassanzadeh, E., Elshorbagy, A., Wheater, H., Gober, P., & Nazemi, A. (2015). Integrating Supply Uncertainties from Stochastic Modeling into Integrated Water Resource Management: Case Study of the Saskatchewan River Basin. Journal of Water Resources Planning and Management, 142(2), 05015006. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000581

Hausman, J., & McFadden, D. (1984). Specification Tests for the Multinomial Logit Model. Econometrica, 52(5), 1219. https://doi.org/10.2307/1910997

Herriges, J. A., & Kling, C. L. (1999). Nonlinear income effects in random utility models. Review of Economics and Statistics, 81(1), 62–72. https://doi.org/10.1162/003465399767923827

Hess, S., & Palma, D. (2021). Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application version 0.2.4 User manual. www.ApolloChoiceModelling.com

Hess, S., & Polak, J. W. (2005). Mixed logit modelling of airport choice in multi-airport regions. Journal of Air Transport Management, 11(2), 59–68. https://doi.org/10.1016/J.JAIRTRAMAN.2004.09.001

Hess, S., Stathopoulos, A., & Daly, A. (2011). Allowing for heterogeneous decision rules in discrete choice models: an approach and four case studies. Transportation 2011 39:3, 39(3), 565–591. https://doi.org/10.1007/S11116-011-9365-6

Holmes, T. P., & Adamowicz, W. L. (2003). Attribute-Based Methods. In A primer on Nonmarket Valuation (pp. 171–219). Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0826-6_6

Hoyos, D. (2010). The state of the art of environmental valuation with discrete choice experiments. Ecological Economics, 69(8), 1595–1603. https://doi.org/10.1016/J.ECOLECON.2010.04.011

Hynes, S., Armstrong, C. W., Xuan, B. B., Ankamah-Yeboah, I., Simpson, K., Tinch, R., & Ressurreição, A. (2021). Have environmental preferences and willingness to pay remained stable before and during the global Covid-19 shock? Ecological Economics, 189. https://doi.org/10.1016/J.ECOLECON.2021.107142

Ingelson, A. E. (2019). Environment in the Courtroom. University of Calgary Press. http://www.hdl.handle.net/1880/109483

IPSOS. (2011). Nine in Ten (87%) Canadians Say That When Connected to Nature They Feel Happier. http://www.ipsos-na.com/news/

Irland, B. (2017). What the River Knows: Saskatchewan Delta at Cumberland House, Canada. National Geographic Society Newsroom. https://blog.nationalgeographic.org/2017/07/01/what-the-river-knows-saskatchewan-delta-at-cumberland-house-canada/

Iyengar, S. S., & Kamenica, E. (2010). Choice proliferation, simplicity seeking, and asset allocation. Journal of Public Economics, 94(7–8), 530–539. https://doi.org/10.1016/J.JPUBECO.2010.03.006

Johnson, E. W., & Schwadel, P. (2018). It Is Not a Cohort Thing: Interrogating the Relationship Between Age, Cohort, and Support for the Environment: Https://Doi.Org/10.1177/0013916518780483, 51(7), 879–901. https://doi.org/10.1177/0013916518780483

Johnston, R. J., Boyle, K. J., Adamowicz, V., Bennett, J., Brouwer, R., Cameron, T. A., Hanemann, W. M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., & Vossler, C. A. (2017). Contemporary Guidance for Stated Preference Studies. https://doi.org/10.1086/691697

Kahneman, D., & Knetsch, J. L. (1992). Valuing Public Goods: The Purchase of Moral Satisfaction*'. Journal of Environmental Economics and Management.

Kanninen, B. J., & Bateman, I. J. (2006). Valuing Environmental Amenities Using Stated Choice Studies A Common Sense Approach to Theory and Practice. Springer. www.springer.com

Kling, C. L. (1989). The Importance of Functional Form in the Estimation of Welfare. Western Journal of Agricultural Economics, 14(1), 168–174. https://www-jstor-org.cyber.usask.ca/stable/40988022?sid=primo&seq=1

Kling, C. L., Phaneuf, D. J., & Zhao, J. (2012). From Exxon to BP: Has Some Number Become Better than No Number? Journal of Economic Perspectives, 26(4), 3–26. https://doi.org/10.1257/jep.26.4.3

Krutilla, J. V. (1967). Conservation Reconsidered. The American Economic Review , 57(4), 777–786. https://media.rff.org/archive/files/sharepoint/News/Features/Documents/071003Krutilla-ConservationReconsidered.pdf

Kulshreshtha, S. N., & Gillies, J. A. (1994). The economic value of the South Saskatchewan River to the city of Saskatoon: (iii) value of alternative minimum river water flow. Canadian Water Resources Journal, 19(1), 39–55. https://doi.org/10.4296/CWRJ1901039

Kulshreshtha, S. N., Gillies, J. A., Kulshreshthal, S. N., & Gillies2, J. A. (1993). The economic value of the South Saskatchewan River to the city of Saskatoon: (i) valuation framework and value estimates for selected uses. Canadian Water Resources Journal, 18(3), 199. https://doi.org/10.4296/cwrj1803199

Kulshreshtha, S., Nagy, C., & Bogdan, A. (2012). Present and Future Water Demand in the South Saskatchewan River Basin A report prepared for SASKATCHEWAN WATERSHED AUTHORITY MOOSE JAW.

Lake Sturgeon (Acipenser fulvescens) COSEWIC Assessment Summary. (2006). https://registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/as_acipenser_fulvescens_e.pdf

Langford, I. H., Skourtos, M. S., Kontogianni, A., Day, R. J., Georgiou, S., & Bateman, I. J. (2001). Use and Nonuse Values for Conserving Endangered Species: The Case of the Mediterranean Monk Seal: Http://Dx.Doi.Org/10.1068/A348, 33(12), 2219–2233. https://doi.org/10.1068/A348

Layton, D. F., & Brown, G. (2000). Heterogeneous Preferences Regarding Global Climate Change. The Review of Economics and Statistics, 82(4), 616–624. https://doi.org/10.1162/003465300559091

Liu, P., Bi, X., Luo, Q., & Whitehead, J. C. (2020). Effects of Policy Consequentiality and Payment Vehicle on Contingent Valuation: Structural Estimates on Preference Misrepresentation. SSRN Electronic Journal. https://doi.org/10.2139/SSRN.3577847

Lloyd-Smith, P., & Adamowicz, W. (2018). Can stated measures of willingness-to-accept be valid? Evidence from laboratory experiments. Journal of Environmental Economics and Management, 91, 133–149. https://doi.org/10.1016/J.JEEM.2018.07.003

Lloyd-Smith, P., Zawojska, E., & Adamowicz, W. (2020). Moving beyond the contingent valuation versus choice experiment debate: Presentation effects in stated preference. Land Economics, 96(1), 1–24. https://doi.org/10.3368/LE.96.1.1

Loomis, J. (2006). Importance of Including Use and Passive Use Values of River and Lake Restoration Universities CoUnCil on Water resoUrCes. Journal of Contemporary Water Research & Education, 134, 4–8.

Loomis, J. B. (1996). Measuring the Economic Benefits of Removing Dams and Restoring the Elwha River: Results of a Contingent Valuation Survey. Water Resources Research, 32(2), 441–447. https://doi.org/10.1029/95WR03243

Loucks, D. P. (2019). Developed river deltas: Are they sustainable? In Environmental Research Letters (Vol. 14, Issue 11). Institute of Physics Publishing. https://doi.org/10.1088/1748-9326/ab4165

Lusk, J. L. (2002). Effects of Cheap Talk on Consumer Willingness-to-Pay for Golden Rice.

Manski, C. F. (2001). Daniel McFadden and the Econometric Analysis of Discrete Choice. In Source: The Scandinavian Journal of Economics (Vol. 103, Issue 2).

Marco, M. Di, Baker, M. L., Daszak, P., de Barro, P., Eskew, E. A., Godde, C. M., Harwood, T. D., Herrero, M., Hoskins, A. J., Johnson, E., Karesh, W. B., Machalaba, C., Garcia, J. N., Paini, D., Pirzl, R., Smith, M. S., Zambrana-Torrelio, C., & Ferrier, S. (2020). Opinion: Sustainable development must account for pandemic risk. Proceedings of the National Academy of Sciences, 117(8), 3888–3892. https://doi.org/10.1073/PNAS.2001655117

Mariel, P., & Artabe, A. (2020). Interpreting correlated random parameters in choice experiments. Journal of Environmental Economics and Management, 203. https://doi.org/10.1016/j.jeem.2020.102363

Mariel, P., Demel, S., & Longo, A. (2021). Modelling welfare estimates in discrete choice experiments for seaweed-based renewable energy. PLoS ONE, 16(11 November). https://doi.org/10.1371/journal.pone.0260352

Mariel, P., Hoyos, D., Meyerhoff, J., Czajkowski, M., Dekker, T., Glenk, K., Jacobsen, J. B., Liebe, U., Olsen, S. B., Sagebiel, J., & Thiene, M. (2021). Econometric Modelling: Extensions. In Environmental valuation with discrete choice experiments. Guidance on design, implementation and data analysis (pp. 83–101). Springer, Cham. https://doi.org/10.1007/978-3-030-62669-3_6

Mariel, P., Hoyos, D., Meyerhoff, J., Czajkowski, M., Dekker, T., Glenk, K., Jacobsen, J. B., Sagebiel, J., & Thiene, M. (2021). Environmental Valuation with Discrete Choice Experiments. Guidance on Design, Implementation and Data Analysis. SpringerBriefs in Economics.

https://library.oapen.org/viewer/web/viewer.html?file=/bitstream/handle/20.500.12657/43295/2021_Book_EnvironmentalValuationWithDisc.pdf?sequence=1&isAllowed=y

Marwell, G., & Ames, R. E. (1981). Economists free ride, does anyone else? Experiments on the provision of public goods, IV. Journal of Public Economics, 15, 295–310.

Mcclelland, G. H., Schulze, W. D., Lazo, J. K., Waldman, D. M., Doyle, J. K., Elliott, S. R., Irwin, J. R., & Carlin, A. (1992). Innovative approaches for valuing perceived environmental quality for measuring non-use values: a contingent valuation study of groundwater cleanup.

McFadden, D. (1973). Chapter four: Conditional logit analysis of qualitative choice behavior. https://eml.berkeley.edu/reprints/mcfadden/zarembka.pdf

McFadden, D. (1974). The measurement of urban travel demand. Journal of Public Economics, 3, 303–328.

McLeod, C., Hildebrand, L., & Radford, D. (1999). A synopsis of lake sturgeon management in Alberta, Canada. Journal of Applied Ichthyology, 15(4–5), 173–179. https://doi.org/10.1111/j.1439-0426.1999.tb00228.x

Medellín-Azuara, J., Durand, J., Fleenor, W., Hanak, E., Lund, J., Moyle, P., & Phillips, C. (2013). Costs of Ecosystem Management Actions for the Sacramento-San Joaquin Delta. http://www.ppic.org/main/home.asp

Meginnis, K. T. (2018). Strategic Bias in Discrete Choice Experiments. University of Manchester.

Meyerhoff, J., & Glenk, K. (2015). Learning how to choose—effects of instructional choice sets in discrete choice experiments. Resource and Energy Economics, 41, 122–142. https://doi.org/10.1016/J.RESENEECO.2015.04.006

Mitchell, R. C., & Carson, R. T. (1989). Using Surveys to Value Public Goods: The Contingent Valuation Method. In Using Surveys to Value Public Goods. Resources for the Future Press. https://doi.org/10.4324/9781315060569

Molnar, M., Olmstead, P., Mitchell, M., Raudsepp-Hearne, C., & Anielski, M. (2021). Canada in a Changing Climate: National Issues Report – Ecosystem Services. In Ecosystem Services; Chapter 5 in Canada in Changing Climate: National Issues Report.

Morey, E., & Greer Rossmann, K. (2003). Using Stated-Preference Questions to Investigate Variations in Willingness to Pay for Preserving Marble Monuments:

Classic Heterogeneity, Random Parameters, and Mixture Models. Journal of Cultural Economics 2003 27:3, 27(3), 215–229. https://doi.org/10.1023/A:1026365125898

Morrison, A. N., & Riddell, C. H. (2012). Opaskwayak Cree Nation Wetland Ethnoecology: Land, Identity and Well-being in a Flooded Landscape.

Nichols, R. J., Hutton, C. W., Adger, W. N., Hanson, S. E., & Salehin, M. (2018). Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis (R. J. Nicholls, Adger W. Neil, Rahman Md. Munsur, Hutton Craig W., Hanson Susan E., & Salehin Mashfiqus (Eds.)). palgrave macmillan .

Nicosia, K., Daaram, S., Edelman, B., Gedrich, L., He, E., McNeilly, S., Shenoy, V., Velagapudi, A., Wu, W., Zhang, L., Barvalia, A., Bokka, V., Chan, B., Chiu, J., Dhulipalla, S., Hernandez, V., Jeon, J., Kanukollu, P., Kravets, P., … Gray, S. (2014). Determining the willingness to pay for ecosystem service restoration in a degraded coastal watershed: A ninth grade investigation. Ecological Economics, 104, 145–151. https://doi.org/10.1016/J.ECOLECON.2014.02.010

Patrick, R., & Baijius, W. (2021). A Parallel Approach to Water Stewardship Planning. Canadian Planning and Policy / Aménagement et Politique Au Canada, 2021, 1–16. https://doi.org/10.24908/cpp-apc.v2021i01.13176

Pattison, J. K. (2009). The Non-Market Valuation of Wetland Restoration and Retention in Manitoba. University of Alberta.

Pattison, J., Boxall, P. C., & Adamowicz, W. L. (2011). The Economic Benefits of Wetland Retention and Restoration in Manitoba. Canadian Journal of Agricultural Economics , 59, 223–244. https://doi.org/10.1111/j.1744-7976.2010.01217.x

Pearce, D., Atkinson, G., & Mourato, S. (2006). Cost-benefit analysis and the environment: Recent developments. In Cost-benefit analysis and the environment: Recent developments (Vol. 9789264010055). Organisation for Economic Cooperation and Development (OECD). https://doi.org/10.1787/9789264010055-EN

Pennington, M., Gomes, M., Donaldson, C., & Centre, G. (2017). Handling protest responses in Contingent Valuation surveys.

Pollock, M. (2012). Saskatchewan River Sturgeon Report. https://www.wsask.ca/wp-content/uploads/2021/03/2012-Sturgeon-Report-Final.pdf

Rice, J., Seixas, C. S., Zaccagnini, M. E., Beodya-Gaitan, M., & Valderrama, N. (2018). The IPBES regional Assessment report on biodiversity and ecosystem services for the Americas. https://ipbes.net/assessment-reports/americas

Roy, S. G., Uchida, E., de Souza, S. P., Blachly, B., Fox, E., Gardner, K., Gold, A. J., Jansujwicz, J., Klein, S., BcGreavy, B., Mo, W., Smith, S. M. C., Vogler, E., Wilson, K., Zydlewski, J., & Hart, D. (2018). A multiscale approach to balance trade-offs among dam infrastructure, river restoration, and cost. Proceedings of the National Academy of Sciences of the United States of America, 115(47), 12069–12074. https://doi.org/10.1073/pnas.1807437115

Rudd, M. A., Andres, S., & Kilfoil, M. (2016a). Non-use Economic Values for Little-Known Aquatic Species at Risk: Comparing Choice Experiment Results from Surveys Focused on Species, Guilds, and Ecosystems. Environmental Management, 58(3), 476. https://doi.org/10.1007/S00267-016-0716-0

Rudd, M. A., Andres, S., & Kilfoil, M. (2016b). Non-use Economic Values for Little-Known Aquatic Species at Risk: Comparing Choice Experiment Results from Surveys Focused on Species, Guilds, and Ecosystems. Environmental Management, 58(3), 476–490. https://doi.org/10.1007/s00267-016-0716-0

Sagintayev, Z., Sizo, A., & Jardine, T. (2015). A water coverage extraction approach to track inundation in the Environmental Data Management System for Site Remediation View project Community Based Fish Health Monitoring View project. Canada Article in International Journal of Remote Sensing. https://doi.org/10.1080/01431161.2014.1001084

Samarawickrema, A., & Kulshreshtha, S. (2008). Value of Irrigation Water for Crop Production in the South Saskatchewan River Basin. Canadian Water Resources Journal, 33(3), 257–272. https://doi.org/10.4296/cwrj3303257

Sask River Delta Conservation Initiative. (n.d.). Protecting the Delta — Saskatchewan River Delta. Retrieved June 27, 2022, from https://www.saskriverdelta.com/why-the-delta-needs-protection

Saskatchewan - Saskatchewan's State of the Environment- Water allocations. (2021). Retrieved from https://www.saskatchewan.ca/residents/environment-public-health-and-safety/state-of-the-environment/saskatchewans-state-of-the-environment/water-allocations

Schindler, D. W., & Donahue, W. F. (2006). An impending water crisis in Canada's western prairie provinces. Proceedings of the National Academy of Sciences of the

United States of America, 103(19), 7210–7216. https://doi.org/10.1073/pnas.0601568103

Schultz, E. T., Johnston, R., Segerson, K., Besedin, E. Y., Schultz, E. T. ;, Johnston, R. ;, & Segerson, K. ; (2012). Integrating Ecology and Economics for Restoration: Using Ecological Indicators in Valuation of Ecosystem Services. https://opencommons.uconn.edu/eeb_articleshttps://opencommons.uconn.edu/eeb_articles/28

Scott, W. B., & Crossman, E. J. (1973). Freshwater fishes of Canada (Bulletin 184). Fisheries Research Board of Canada. https://publications.gc.ca/collections/collection_2019/mpo-dfo/Fs94-184-eng.pdf

Scruton, D. A., & Ledrew, L. J. (1997). A retrospective assessment of the flow regulation of the West Salmon River, Newfoundland, Canada. Fisheries Management and Ecology, 4(6), 467–480. https://doi.org/10.1046/J.1365-2400.1997.T01-1-00099.X

Shi, H., Zhao, M., Asefaw Aregay, F., Zhao, K., & Jiang, Z. (2016). Residential Environment Induced Preference Heterogeneity for River Ecosystem Service Improvements: A Comparison between Urban and Rural Households in the Wei River Basin, China. https://doi.org/10.1155/2016/6253915

Shonkwiler, J. S., & Shaw, W. D. (2003). A finite mixture approach to analyzing income effects in random utility models: Reservoir recreation along the Columbia river. In The New Economics of Outdoor Recreation (pp. 268–279). Edward Elgar Publishing. https://doi.org/10.4337/9781781950319.00023

Smith, V. K., & Gilbert, C. C. S. (1985). The Valuation of Environmental Risks Using Hedonic Wage Models. In Horizontal Equity, Uncertainty, and Economic Well-Being (pp. 359–392).

South Saskatchewan River Watershed Stewards.(n.d.) About The South Saskatchewan River Basin. Retrieved August 1, 2022, from https://southsaskriverstewards.ca/south-sk-river/

Species at Risk Public Registry. (2017). COSEWIC assessment and status report on the Lake Sturgeon Acipenser fulvescens, Western Hudson Bay populations, Saskatchewan-Nelson River populations, Southern Hudson Bay-James Bay populations and Great Lakes-Upper St. Lawrence populations in Canada. www.sararegistry.gc.ca/status/status_e.cfm

Statistics Canada. (2017). Population size and growth in Canada: Key results from the 2016 Census. https://www150.statcan.gc.ca/n1/daily-quotidien/170208/dq170208a-eng.htm

Statistics Canada. (2019). 2016 Census of Population – Data products. (2016). https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/index-eng.cfm

Svedsäter, H. (2003). Economic valuation of the environment: How citizens make sense of contingent valuation questions. Land Economics, 79(1), 122–135. https://doi.org/10.2307/3147109

Sverrisson, D., Boxall, P. C., & Adamowicz, V. (2008). Estimation of the Passive Use Values Associated with Future Expansion of Provincial Parks and Protected Areas in Southern Ontario .

Tanguay, M., Adamowicz, W. L., & Boxall, P. (1995). An Economic Evaluation of Woodland Caribou Conservation Programs in Northwestern Saskatchewan.

Traets, F., Sanchez, D. G., & Vandebroek, M. (2020). Generating Optimal Designs for Discrete Choice Experiments in R: The idefix Package. Journal of Statistical Software, 96(3). https://doi.org/10.18637/jss.v000.i00

Train, K. (1999). Halton Sequences for Mixed Logit. http://elsa.berkeley.edu/~train.

Train, K. (2002). Discrete Choice Methods with Simulation. Cambridge University Press.

Treasury Board of Canada Secretariat. 2007. Assessing, Selecting, and Implementing Instruments for Government Action. http://www.tbs-sct.gc.ca.

Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. Science, 185(4157), 1124–1131. https://doi.org/10.1126/SCIENCE.185.4157.1124

U.S. Inflation Calculator. (n.d.). Inflation Calculator | Find US Dollar's Value from 1913-2022. (n.d.). Retrieved August 1, 2022, from https://www.usinflationcalculator.com/

Van den Broek-Altenburg, E., & Atherly, A. (2020). Using discrete choice experiments to measure preferences for hard to observe choice attributes to inform health policy decisions. Health Economics Review, 10(18). https://doi.org/https://doi.org/10.1186/s13561-020-00276-x

Verbeek, M. (2004). A Guide to Modern Econometrics 2nd edition.

Volke, M. A., Scott, M. L., Johnson, W. C., & Dixon, M. D. (2015). The ecological significance of emerging deltas in regulated rivers. BioScience, 65(6), 598–611.

Vorosmarty, C. J., Syvitski, J., Day, J., De Sherbinin, A., Giosan, L., & Paola, C. (2009). Battling to save the world's river deltas. In Bulletin of the Atomic Scientists. https://journals.sagepub.com/doi/pdf/10.2968/065002005

Warick, J. (2020, July). Water, water everywhere? Some question true costs of Sask's $4B irrigation plan | CBC News. CBC News. https://www.cbc.ca/news/canada/saskatoon/water-water-everywhere-some-question-true-costs-of-sask-s-4b-irrigation-plan-1.5653355

Watchorn, K. E. (2011). Effects of Water Level Management on Water Chemistry and Primary Production of Boreal Marshes in Northern Manitoba, Canada.

Watkinson, D. A., Ghamry, H. K., & Enders, E. C. (2020). Information to support the assessment of the Instream Flow Needs for Fish and Fish Habitat in the Saskatchewan River downstream of the E.B. Campbell Hydroelectric Station. https://publications.gc.ca/collections/collection_2020/mpo-dfo/fs70-5/Fs70-5-2018-058-eng.pdf

Watson, J. E. M., Venter, O., Lee, J., Jones, K. R., Robinson, J. G., Possingam, H. P., & Allan, J. R. (2018). Protect the last of the wild. Nature, 563, 27–30.

Weber, M., & Cutlac, M. (2014). Economic and environmental tradeoffs from alternative water allocation policies in the South Saskatchewan River Basin Economic and environmental tradeoffs from alternative water allocation policies in the South Saskatchewan River Basin. Canadian Water Resources Journal. https://doi.org/10.1080/07011784.2014.965040

Wells, J., Childs, D., Siegers, S. M., & Badiou, P. (2014). Manitoba's Blue Mosaic.

Wright, P. A., Moghimehfar, F., & Woodley, A. (2019). Canadians' perspectives on how much space nature needs. https://doi.org/10.1139/facets-2018-0030

Appendix A- Saskatchewan River Delta Stated Preference Survey

Managing the Saskatchewan River Delta

What is Your Opinion?

You are invited to participate in a research study about the Saskatchewan River Delta

Patrick Lloyd-Smith, Assistant Professor, Department of Agricultural and Resource Economics, University of Saskatchewan, patrick.lloydsmith@usask.ca

Elisabeta Lika, Graduate Student, Department of Agricultural and Resource Economics, University of Saskatchewan

Ken Belcher, Professor, Department of Agricultural and Resource Economics, University of Saskatchewan

<u>Purpose and Objective of the Research:</u> The purpose of this research study is to understand people's opinions and attitudes for management of the Saskatchewan River Delta ecosystem.

<u>Procedures:</u> We are asking you to take part in a survey being held across Canada. The estimated time to complete this is about 20 minutes.

<u>Funded by:</u> The study is being funded by the Social Sciences and Humanities Research Council of Canada and the Global Institute for Water Security at the University of Saskatchewan.

<u>Potential Risks:</u> There are no known or foreseen risks associated with participation in this study.

<u>Potential Benefits:</u> Survey participants will help inform future decisions regarding conservation and development in the Saskatchewan River Basin.

<u>Confidentiality:</u> All information you provide is considered confidential and grouped with responses from other participants. Names will not be associated with survey responses. Access to the data will be restricted to the investigators. The survey is being collected using

Voxco, a Canadian-owned and managed company whose data is securely stored in Canada. Information on Voxco's privacy policy is available here https://www.voxco.com/privacy-policy/.

Storage of Data: Electronic survey data will be stored on a password-protected research-dedicated computer, with access restricted to the researchers. Anonymous survey response data will be stored indefinitely.

Right to Withdraw: Participation in this survey is voluntary. You can decide not to participate at any time by closing your browser. Survey responses will remain confidential. Once the survey has been completed you cannot withdraw the information you provided.

Questions or Concerns: Contact the researcher(s) using the information at the top of screen. This research project has been approved on ethical grounds by the University of Saskatchewan Behavioural Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office: ethics.office@usask.ca; 306-966-2975; out of town participants may call toll free 1-888-966-2975.

Completion of the survey constitutes your consent to participate in this research.

In which province or territory do you currently reside?

- Alberta
- British Columbia
- Manitoba
- New Brunswick
- Newfoundland and Labrador
- Northwest Territories
- Nova Scotia
- Nunavut
- Ontario
- Prince Edward Island
- Quebec

- Saskatchewan
- Yukon

Federal and provincial governments in Canada, working with local communities, face decisions about how to manage natural areas.

A representative group of citizens in Canada has been randomly selected to answer the questionnaire, including you. Your answers are important, whether or not you are interested in the topic. This survey will help these decision makers know what you would like to see happen in the Saskatchewan River Delta.

To help make these decisions, we ask for you to please read the carefully information about the Saskatchewan River Delta.

- I have read and understood these instructions

The Saskatchewan River Delta is located at the border of Saskatchewan and Manitoba and is downstream of the Saskatchewan River. A map showing the location of the delta is provided below along with a short description of the study area.

[Source: Understanding, Managing, and Preserving the Saskatchewan River Delta 2018]

Geography

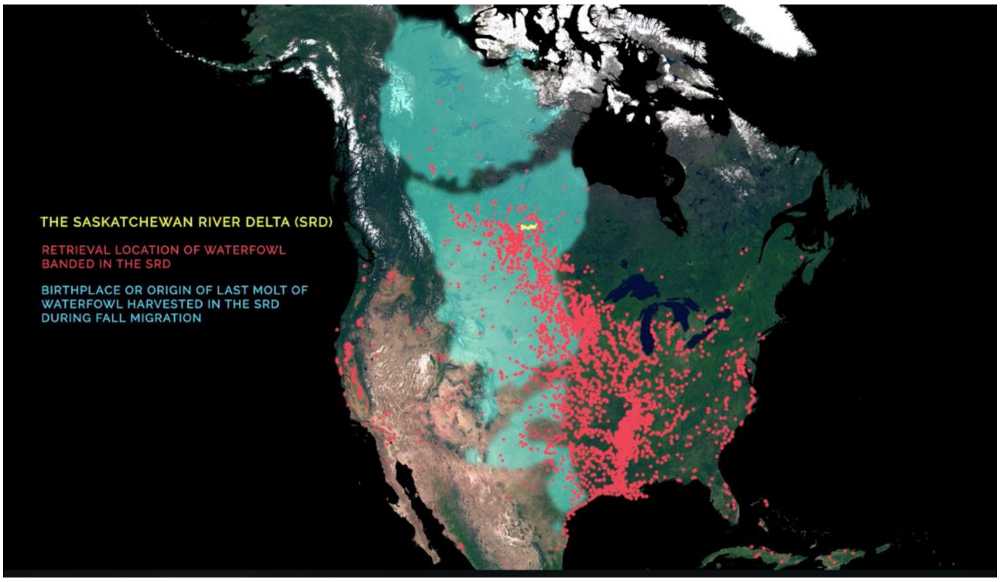
- The Saskatchewan River Delta is a network of waterways, wetlands, and forests covering an area of about 1 million hectares and is one of the largest inland freshwater deltas in North America and is almost twice as large as Prince Edward Island.
- The delta is fed by the South and North Saskatchewan rivers draining much of Alberta and Saskatchewan. Water in the delta drains into Lake Winnipeg and Manitoba.

People

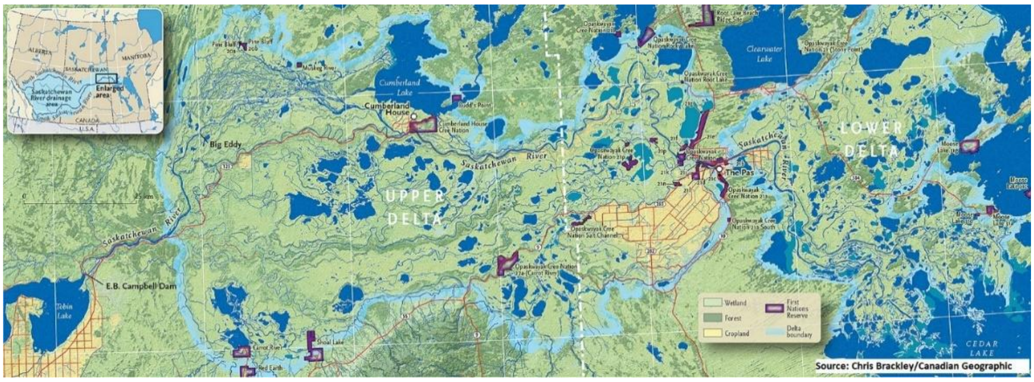
- The delta is the traditional territory for the Cumberland House Cree Nation, Peter Ballantyne Cree Nation, Opaskwayak Cree Nation, and Métis Nation communities who continue to rely on its ecosystems for food, livelihoods, economic opportunities, and cultural connection.
- Approximately 15,000 people live in the delta.

Fish and Wildlife

- The delta is over 80 percent wetland and contains at least 43 species of mammals, 48 species of fish, and over 200 different species of birds.
- Birds from all across North America visit the delta during their life and the area is recognized as an internationally important waterfowl breeding area (click here for a map).
- The delta is also home to species at risk including the Lake Sturgeon.



Click here to see an enlarge map of the study area *[insert hyperlink to map below]*



1. **Before** starting this survey, had you heard of the Saskatchewan River Delta?

___No

___Yes

Don't know

2. Have you ever visited the Saskatchewan River Delta?

___Yes

___No

Don't know

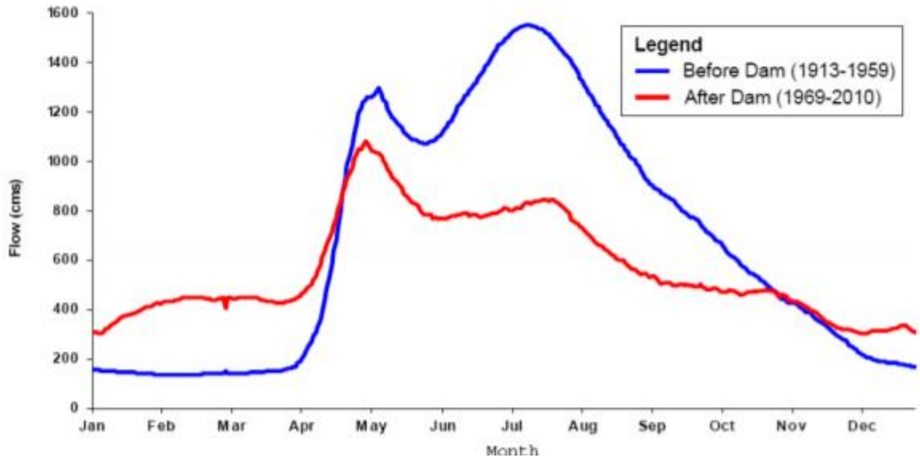
Saskatchewan River Delta Status and Impacts

The Saskatchewan River is used for a variety of purposes that benefit society including:

- **Hydropower:** There are several dams used to generate electricity along the Saskatchewan River including the E.B. Campbell Dam just upstream of the delta. There is also the Grand Rapids Dam at the lower end of the delta.
- **Agricultural Irrigation:** Water is used to support crop and livestock production in Alberta and Saskatchewan.
- **Industrial use:** Water is used in industrial processes in mining, manufacturing, and oil and gas activities.
- **Household use:** Water is used for drinking, cooking, cleaning and sanitation.

However, these activities are also having impacts downstream in the Saskatchewan River Delta ecosystem. These impacts include:

- **Changes to the timing of seasonal water flows into the delta.** Compared to natural conditions, more water is released by dams during the winter and less water in the spring and summer. This has led to a decrease in the frequency of flooding to wetlands which provide habitat for fish and wildlife. The figure below shows the average weekly river flows into the Saskatchewan River Delta before and after dam construction in 1968.



[Source: Michael David Ervin 2011]

- **Changes to the timing of daily water flows into the delta.** Water released from hydro dams to match electricity demands means rapid increases and decreases in water levels every day which negatively impacts fish and wildlife.
- **Lower overall water flows into the delta** due to upstream water consumption means less habitat for fish and wildlife.
- **Drier conditions within the** Saskatchewan River Delta. Overbank flooding historically occurred once every 12 years on average but now flooding is estimated to occur on average once every 45 years.
- **Reduced sediment supply into the delta** has increased erosion and decreased water connections to side channels and wetlands.
- **Increased water pollutants** entering the delta from human activities has impacts on the water quality and aquatic life in the delta.
- **Increased invasive species** such as reed grass (Phragmites) have reduced habitat quality for fish and wildlife.
- **Natural habitat loss** due to the permanent flooding of about 100,000 hectares to create the reservoir for the Grand Rapids Dam and around 50,000 hectares of wetlands have been drained for agricultural developments.

3. After reading the information about the various uses of the Saskatchewan River and downstream impacts, how concerned are you, if at all, about the delta ecosystem?

Extremely concerned

Very concerned

Moderately concerned

Somewhat concerned

Not at all concerned

Don't know

People are interested in taking action to conserve natural areas for a variety of reasons that may include:

- Natural areas are a source of recreation, enjoyment and learning for people now and in the future.
- Natural areas help to maintain a healthy ecosystem and should not be endangered by human actions.
- Natural areas are culturally and economically important to Indigenous peoples.

People are concerned about taking action to conserve natural areas for a variety of reasons that may include:

- There may be restrictions placed on what people can do, including limits on agricultural activities, industrial development, and land uses.
- There may be an increase in the cost of producing products such as food, electricity, housing, and transportation, which may increase the prices consumers pay.
- Protecting natural areas diverts government funding away from other important uses.

[If Group = A1 or A2 (WTP)]

New Conservation Actions for the Saskatchewan River Delta

The federal and provincial governments, in collaboration with local communities and private conservation groups, are considering several actions and tools to improve the condition of the delta. The tools available are:

River flow controls – Dam managers can modify the water releases from the dams to better mimic the natural pattern of water flow by changing the timing, fluctuations, and average flows into the delta.

Water use efficiency -- Irrigators can reduce upstream water withdrawals by improving irrigation water use efficiency and industrial users can increase water recycling in production processes.

Fish and wildlife habitat restoration – Resource managers can actively restore native fish and waterfowl habitat by using various tools designed to partially control weeds or improve the movement of water. These control tools affect the growth and survival of the fish species and promote healthy waterfowl populations.

Water pollution controls – Implement regulations and policies to reduce agricultural run-off and industrial pollutants entering the river upstream of the delta.

Cost of tools -- Water managers are able to use these tools in combinations in order to benefit the delta ecosystem. These actions come with costs, which include the following

- Reduced electricity from dams
- Reduced agricultural production
- Money for active restoration

If conservation actions are taken in the delta, it will cost every household more money.

- The federal government is considering a fixed annual tax increase that would be invested in a Saskatchewan River Delta conservation fund.
- The increase in annual taxes is expected to last for a period of 20 years while the primary conservation activities take place.

Assume that the costs for using the management tools mentioned above for your household (and similar households in your area) would begin in 2022 and would last for the next 20 years.

4. How much do you agree or disagree with the following statement?

Even if it costs households more money, we should do more to conserve the Saskatchewan River Delta.

__Strongly Agree

__Agree

__Somewhat Agree

__Neither Agree nor Disagree

__Somewhat Disagree

__Disagree

__Strongly Disagree

__Not sure

[If Group = B1 or B2 (WTA)]

New Developments Affecting the Saskatchewan River Delta

Governments are currently considering additional upstream development in the Saskatchewan River Basin that are expected to degrade the natural resource conditions in the delta unless mitigation activities are undertaken. The development and mitigation activities are:

Expanded irrigation: Alberta and Saskatchewan are planning to substantially increase irrigation which will require additional water withdrawals, leaving less water for the delta ecosystem. Increased agricultural production may result in additional pollutants entering the river and flowing downstream into the delta.

Industrial development: Additional mining and industrial projects that require more water to be used for cooling and the production process.

Mitigation tools: The government can also undertake projects to mitigate the adverse impacts of future developments on the delta. These activities can include

- River flow controls to better mimic natural water flow
- Water use efficiency to increase water flows to the delta
- Water quality improvements to reduce pollution entering the delta, and
- Fish and wildlife habitat restoration.

Increased government revenue – Allowing future irrigation and industrial development will increase government revenue which can be returned to households.

If future development occurs, money will be returned to every household in Canada.

- The government is considering a uniform refundable tax credit that will be used to compensate Canadian households.
- The annual tax credit is expected to last for a period of 20 years while the development activities take place.

Assume that the tax credit given to your household (and similar households in your area) would begin in 2022 and would last for the next 20 years.

5. How much do you agree or disagree with the following statement?

Even if households receive less money, we should mitigate the negative impacts of development on the Saskatchewan River Delta.

__Strongly Agree

__Agree

__Somewhat Agree

__Neither Agree nor Disagree

__Somewhat Disagree

__Disagree

__Strongly Disagree

__Not sure

Environmental Outcomes in the Saskatchewan River Delta

[If Group = A1 or A2 (WTP)] Depending on how conservation activities are done, changes can have different outcomes in the Saskatchewan River Delta.

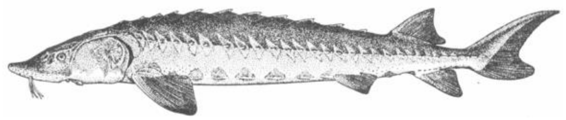
[If Group = B1 or B2 (WTA)] Depending on the extent of upstream development and mitigation activities, changes can have different outcomes in the Saskatchewan River Delta.

The following four environmental outcomes are of interest to this survey:

- Lake Sturgeon
- Waterfowl population
- Muskrat abundance
- Habitat in healthy ecological condition

Please read this carefully to answer the questions in the survey.

Lake Sturgeon



- Lake Sturgeon are one of the largest, longest-lived, freshwater fish species in Canada and have special significance to Indigenous people.
- Lake Sturgeon in the delta are currently listed as endangered by the Committee on the Status of Endangered Wildlife in Canada.
- They are a sensitive indicator of overall aquatic health of the delta ecosystem.
- Population levels in the delta are estimated to be 10% of historical abundance due to past harvests and dam construction.
- The conservation target for the delta population is 10,000 adult fish to allow for subsistence harvest by the local community.

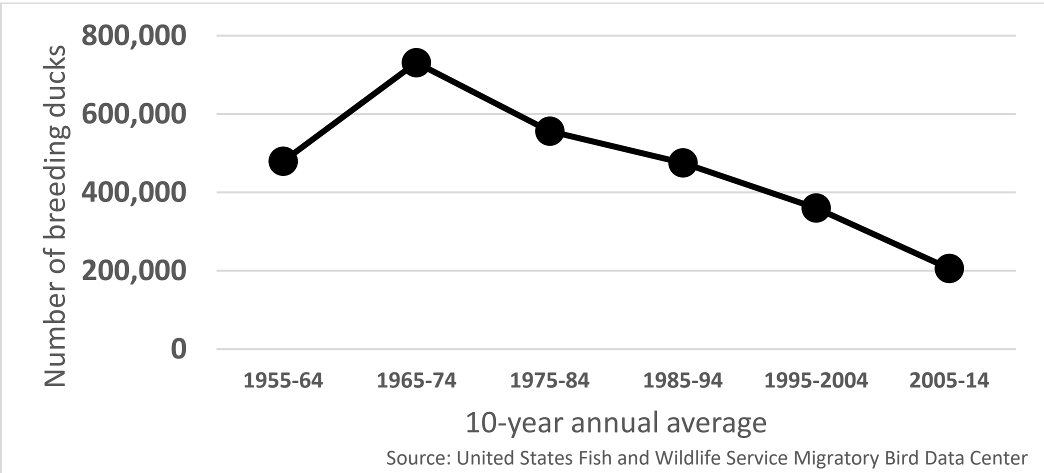
- I have read and understood these instructions

Waterfowl population

- The Saskatchewan River Delta is recognized internationally as an Important Bird Area due to the high concentration of waterfowl
- The area is an important migratory stopover location and contributes significantly to waterfowl populations in North America.

- Hundreds of thousands of ducks nest in the delta each year but these numbers have decreased from around 800,000 during the late 1960s to 200,000 in the 2010s.

10-year annual average for number of breeding ducks in Saskatchewan River Delta



- I have read and understood these instructions

Muskrat abundance

- Muskrats are culturally important for the local community and are harvested for food and their furs.
- Current muskrat harvest levels are 99% below 1960s levels.

- They are particularly sensitive to changing water levels and upstream river flow alterations and ecological deterioration have led to population declines in the delta.
- Muskrat abundance is an important indicator of overall wetland ecosystem health
  - ▪ I have read and understood these instructions

Habitat in healthy ecological condition

- The abundance and diversity of wildlife in the delta depends on the ecological health of streams, lakes, wetlands, and uplands.
- Habitat degradation and loss has occurred in the delta due to
  - Less water and sediments entering the delta
  - Permanent flooding of wetlands for hydropower reservoirs (100,000 hectares)
  - Conversion of wetlands to agriculture (50,000 hectares)
  - Invasive species that out-compete native species for water and nutrients such as an aggressive plant named Phragmites (European Common Reed).
- Healthy ecological condition is measured using local Indigenous knowledge and recognized standards.
- This outcome measures the quantity of the delta in healthy ecological condition.
  - ▪ I have read and understood these instructions

[Survey versions A1 and A2]

Summary of Environmental Outcomes in the Saskatchewan River Delta

The effects of each possible scenario will be described using the following scores:

	What it Means
Lake Sturgeon	A score between 0 and 100 percent showing **the estimated size of the Lake Sturgeon population compared to the conservation target**. A score of 100 means that the population meets the conservation target; 0 means no fish. Without management changes, **the score in the delta will be 35.**
Waterfowl population	A score between 0 and 100 percent showing **the estimated size of waterfowl populations compared to historical levels**. A score of 100 means that

	populations are the largest natural size possible; 0 means no birds. Without management changes, **the score in the delta will be 25.**
Muskrat abundance	A score between 0 and 100 percent showing **the estimated abundance of muskrats compared to historical levels**. A score of 100 means that populations are the largest natural size possible; 0 means no muskrats. Without management changes, **the score in the delta will be 5.**
Habitat in healthy ecological condition	A score between 0 and 100 percent showing **the quantity of habitat in the delta in healthy ecological condition of**. Higher scores mean that more of the delta is in a healthy natural condition. Without management changes, **the score in the delta will be 45.**
Annual cost to your household for 20 years	The amount of money that your household will have to pay each year for 20 years while the primary conservation activities take place.

[Survey versions B1 and B2]

Summary of Environmental Outcomes in the Saskatchewan River Delta

The effects of each possible scenario will be described using the following scores:

	What it Means
Lake Sturgeon	A score between 0 and 100 percent showing **the estimated size of the Lake Sturgeon population compared to the conservation target**. A score of 100 means that the population meets the conservation target; 0 means no fish. Without management changes, **the score in the delta will be 100.**
Waterfowl population	A score between 0 and 100 percent showing **the estimated size of waterfowl populations compared**

	to historical levels. A score of 100 means that populations are the largest natural size possible; 0 means no birds. Without management changes, **the score in the delta will be 75.**
Muskrat abundance	A score between 0 and 100 percent showing **the estimated abundance of muskrats compared to historical levels**. A score of 100 means that populations are the largest natural size possible; 0 means no muskrats. Without management changes, **the score in the delta will be 70.**
Habitat in healthy ecological condition	A score between 0 and 100 percent showing **the quantity of habitat in the delta in healthy ecological condition of**. Higher scores mean that more of the delta is in a healthy natural condition. Without management changes, **the score in the delta will be 85.**
Annual benefit to your household for 20 years	The amount of money that your household will receive each year for 20 years while primary development and mitigation activities take place

Which Saskatchewan River Delta Future Do You Prefer?

Your opinions are important to understand what Saskatchewan River Delta future outcomes the public prefers. The results of this survey are advisory. The survey will inform policymakers on the opinions and preferences of Canadians to help decide if and what actions should be taken that affect the delta.

[Group A1]

Next, we will ask you to make six (6) choices between the outcomes of different Saskatchewan River Delta future alternatives, to indicate which option you prefer. In each question, you are asked to choose between a Status Quo Alternative (leave as is) and two other alternatives (Alternative A and Alternative B):

- The Status Quo Alternative (leave as is) shows expected outcomes over the next 20 years if no new delta conservation projects occurs, and would not increase the costs to your household.
- Alternatives A and B show the expected outcomes over the next 20 years under two of the many potential future scenarios that do more and cost more to conserve the delta. The added cost to your household each year for 20 years is shown for each alternative.

For each question, ask yourself whether you believe the Saskatchewan River Delta improvements offered under Alternatives A or B are worth the additional costs each year to your household over 20 years.

[Group A2]

Next, we will ask you to make a choice between the outcomes of different Saskatchewan River Delta future alternatives, to indicate which option you prefer. You are asked to choose between a Status Quo Alternative (leave as is) and one other alternative (Alternative A):

- The Status Quo Alternative (leave as is) shows expected outcomes over the next 20 years if no new delta conservation projects occurs, and would not increase the costs to your household.
- Alternative A shows the expected outcomes over the next 20 years under a potential future scenario that does more and costs more to conserve the delta. The added cost to your household each year for 20 years is shown.

*A*sk yourself whether you believe the Saskatchewan River Delta improvements offered under Alternative A are worth the additional costs each year to your household over 20 years.

[Group B1]

Next, we will ask you to make six (6) choices between the outcomes of different Saskatchewan River Delta future alternatives, to indicate which option you prefer. In each question, you are asked to choose between a Status Quo Alternative (leave as is) and two other alternatives (Alternative A and Alternative B):

- The Status Quo Alternative (leave as is) shows expected outcomes over the next 20 years if delta conditions remain the same, and would not change the net cost to your household.

- Alternatives A and B show the expected outcomes over the next 20 years under two of the many potential future scenarios that do less to conserve the delta, but result in benefits to households. The added benefit to your household each year for 20 years is shown for each alternative.

For each question, ask yourself whether you believe the Saskatchewan River Delta degradations offered under Alternatives A or B are worth the additional money each year your household would receive over 20 years.

[Group B2]

Next, we will ask you to make a choice between the outcomes of different Saskatchewan River Delta future alternatives, to indicate which option you prefer. You are asked to choose between a Status Quo Alternative (leave as is) and one other alternative (Alternative A):

- The Status Quo Alternative (leave as is) shows expected outcomes over the next 20 years if delta conditions remain the same, and would not change the net cost to your household.
- Alternative A shows the expected outcomes over the next 20 years under a potential future scenario that does less to conserve the delta, but results in benefits to households. The added benefit to your household each year for 20 years is shown.

*A*sk yourself whether you believe the Saskatchewan River Delta degradations offered under Alternative A are worth the additional money you would receive each year to your household over 20 years.

[All survey versions]

There is no right or wrong answer. We have found some people support these alternatives and others do not support them. Both kinds of people have good reasons for why they would choose one way or the other.

It is important that you make each of your upcoming selections like you would if you were **actually** facing these exact choices in reality.

[Group A1 or B1] Please treat each of the following questions individually as a separate choice.

[Group A1 or A2] Remember, paying for environmental improvement means you would have less money available to buy other things.

[Group B1 or B2] Remember, the money you receive as a tax credit can be used to buy other things.

[Group A1 or B1]

[] I am ready to make choices between potential Saskatchewan River Delta futures

[Group A2 or B2]

[] I am ready to make a choice between potential Saskatchewan River Delta futures

[Group A1 Example: 1 of 6 choice sets]

6. Alternatives A and B are potential Saskatchewan River Delta futures. The Status Quo alternative means no new conservation occurs. Given the choice between these three alternatives, how would you vote?

	Results in 20 years		
	Status Quo	Alternative A	Alternative B
Lake Sturgeon	**30%** 3,000 of 10,000 fish conservation target	**15%** 1,500 of 10,000 fish conservation target	**100%** 10,000 of 10,000 fish conservation target
Waterfowl population	**25%** 200,000 of 800,000 breeding ducks possible	**50%** 400,000 of 800,000 breeding ducks possible	**75%** 600,000 of 800,000 breeding ducks possible
Muskrat abundance	**5%** 1 muskrat found per hectare out of 20 possible	**30%** 6 muskrats found per hectare out of 20 possible	**60%** 12 muskrats found per hectare out of 20 possible
Habitat in healthy ecological condition	**45%** 405,000 of 900,000 hectares	**60%** 540,000 of 900,000 hectares	**75%** 675,000 of 900,000 hectares
Annual cost to your household for 20 years	**$0** Increase in annual taxes for 20 years	**$15** Increase in annual taxes for 20 years	**$325** Increase in annual taxes for 20 years
I would vote for…	☐ Status Quo	☐ Alternative A	☐ Alternative B

7. Considering the alternatives outlined above, what do you think a typical person in your neighbourhood would choose if the following options were put to vote in a real referendum?

A typical neighbour of mine would vote for…	☐ Status Quo	☐ Alternative A	☐ Alternative B

[Include the following attribute descriptions below each choice task]

Lake Sturgeon

- Lake Sturgeon are one of the largest, longest-lived, freshwater fish species in Canada and have special significance to Indigenous people.
- Lake Sturgeon in the delta are currently listed as endangered by the Committee on the Status of Endangered Wildlife in Canada.
- They are a sensitive indicator of overall aquatic health of the delta ecosystem.
- Population levels in the delta are estimated to be 10% of historical abundance due to past harvests and dam construction.
- The conservation target for the delta population is 10,000 adult fish to allow for subsistence harvest by the local community.

Waterfowl population

- The Saskatchewan River Delta is recognized internationally as an Important Bird Area due to the high concentration of waterfowl
- The area is an important migratory stopover location and contributes significantly to waterfowl populations in North America.
- Hundreds of thousands of ducks nest in the delta each year but these numbers have decreased from around 800,000 during the late 1960s to 200,000 in the 2010s.

Muskrat abundance

- Muskrats are culturally important for the local community and are harvested for food and their furs.
- Current muskrat harvest levels are 99% below 1960s levels.

- They are particularly sensitive to changing water levels and upstream river flow alterations and ecological deterioration have led to population declines in the delta.
- Muskrat abundance is an important indicator of overall wetland ecosystem health.

Habitat in healthy ecological condition

- The abundance and diversity of wildlife in the delta depends on the ecological health of streams, lakes, wetlands, and uplands.
- Habitat degradation and loss has occurred in the delta due to
  - Less water and sediments entering the delta
  - Permanent flooding of wetlands for hydropower reservoirs (100,000 hectares)
  - Conversion of wetlands to agriculture (50,000 hectares)
  - Invasive species that out-compete native species for water and nutrients such as an aggressive plant named Phragmites (European Common Reed).
- Healthy ecological condition is measured using local Indigenous knowledge and recognized standards.
- This outcome measures the quantity of the delta in healthy ecological condition.

[INCLUDE REST OF CHOICE SETS HERE]

[Group A2]

8. Alternative A is a potential Saskatchewan River Delta future. The Status Quo alternative means no new conservation occurs. Given the choice between these two alternatives, which one would you prefer?

	Result in 20 years	
	Status Quo	Alternative A
Lake Sturgeon population	**35%** 3,500 of 10,000 fish conservation target	**100%** 10,000 of 10,000 fish conservation target
Waterfowl population	**25%** 200,000 of 800,000 breeding ducks possible	**75%** 600,000 of 800,000 breeding ducks possible
Muskrat abundance	**5%** 1 muskrat found per hectare out of 20 possible	**70%** 14 muskrat found per hectare out of 20 possible

Habitat in healthy ecological condition	**45%** 405,000 of 900,000 hectares	**85%** 765,000 of 900,000 hectares
Cost to your household per year for 20 years	**$0** Increase in annual taxes for 20 years	**$[$BIDAMT]** Increase in annual taxes for 20 years
I would vote for…	☐ Status Quo	☐ Alternative A

9. Considering the alternatives outlined above, what do you think a typical person in your neighbourhood would choose if the following options were put to vote in a real referendum?

A typical neighbour of mine would vote for…	☐ Status Quo	☐ Alternative A

[Group B1 Example: 1 of 6 choice sets]

10. Alternatives A and B are potential Saskatchewan River Delta futures. The Status Quo alternative means no new conservation occurs. Given the choice between these three alternatives, how would you vote?

	Results in 20 years		
	Status Quo	Alternative A	Alternative B
Lake Sturgeon	**100%** 10,000 of 10,000 fish conservation target	**30%** 3,000 of 10,000 fish conservation target	**15%** 1,500 of 10,000 fish conservation target
Waterfowl population	**50%** 400,000 of 800,000 breeding ducks possible	**50%** 400,000 of 800,000 breeding ducks possible	**25%** 200,000 of 800,000 breeding ducks possible
Muskrat abundance	**40%** 8 muskrat found per hectare out of 20 possible	**30%** 6 muskrats found per hectare out of 20 possible	**5%** 1 muskrat found per hectare out of 20 possible

Habitat in healthy ecological condition	**60%** 540,000 of 900,000 hectares	**60%** 540,000 of 900,000 hectares	**45%** 405,000 of 900,000 hectares
Annual benefit to your household for 20 years	**$0** Annual tax credit for 20 years	**$15** Annual tax credit for 20 years	**$325** Annual tax credit for 20 years
I would vote for…	☐ Status Quo	☐ Alternative A	☐ Alternative B

11. Considering the alternatives outlined above, what do you think a typical person in your neighbourhood would choose if the following options were put to vote in a real referendum?

A typical neighbour of mine would vote for…	☐ Status Quo	☐ Alternative A	☐ Alternative B

[INCLUDE REST OF CHOICE SETS HERE]

[Group B2]

12. Alternative A is a potential Saskatchewan River Delta future. The Status Quo alternative means no new conservation occurs. Given the choice between these two alternatives, which one would you prefer?

	Result in 20 years	
	Status Quo	Alternative A
Lake Sturgeon population	**100%** 10,000 of 10,000 fish conservation target	**35%** 3,500 of 10,000 fish conservation target
Waterfowl population	**75%** 600,000 of 800,000 breeding ducks possible	**25%** 200,000 of 800,000 breeding ducks possible
Muskrat abundance	**70%** 14 muskrat found per hectare out of 20 possible	**5%** 1 muskrat found per hectare out of 20 possible

Habitat in healthy ecological condition	**85%** 765,000 of 900,000 hectares	**45%** 405,000 of 900,000 hectares
Annual benefit to your household for 20 years	**$0** Annual tax credit for 20 years	**$[$BIDAMT]** Annual tax credit for 20 years
I would vote for…	☐ Status Quo	☐ Alternative A

13. Considering the alternatives outlined above, what do you think a typical person in your neighbourhood would choose if the following options were put to vote in a real referendum?

A typical neighbour of mine would vote for…	☐ Status Quo	☐ Alternative A

[All survey versions: Consequentiality question]

The next four questions are about what you believed when you voted.

14. How would you rate the difficulty in answering the previous Saskatchewan River Delta future scenario questions?

[Likert 5-point scale]

Very easy to answer 1

2

3

4

Very difficult to answer 5

15. When the federal and provincial governments decide whether or not to implement the Saskatchewan River Delta future scenarios you just voted on, how likely do you think it is that the governments will take into account your vote and that of the other respondents to this study in its decision-making?

Very likely Likely Somewhat likely Somewhat unlikely Unlikely Very unlikely

☐ ☐ ☐ ☐

[Group A1: WTP CE version]

16. If one of the alternative scenarios is implemented, how effective do you think it will be at conserving the delta over the next 20 years?

Extremely Effective Very Effective Moderately Effective Slightly Effective Not Effective at All

□ □ □ □ □

17. Did you believe that if one of the alternative scenarios is implemented, you and your family would be charged the annual tax shown for the next 20 years, more than annual tax shown, or less than annual tax shown?

□ Charge annual tax shown

□ Charge more

□ Charge less

[Group A2: WTP CONTINGENT VALUATION version]

If the alternative scenario is implemented, how effective do you think it will be at conserving the Saskatchewan River Delta over the next 20 years?

Extremely Effective Very Effective Moderately Effective Slightly Effective Not Effective at All

□ □ □ □ □

Did you believe that if the alternative scenario is implemented, you and your family would be charged an annual tax of [$BIDAMT] for the next 20 years, more than [$BIDAMT], or less than [$BIDAMT]?

□ Charge [$BIDAMT]

□ Charge more

□ Charge less

[Group B1: WTA CE version]

If the status quo scenario is implemented, how effective do you think it will be at conserving the Saskatchewan River Delta over the next 20 years?

Extremely Effective Very Effective Moderately Effective Slightly Effective Not Effective at All

☐ ☐ ☐ ☐ ☐

Did you believe that if one of the alternative scenarios is implemented, you and your family would be paid the annual tax credit shown for the next 20 years, more than annual tax credit shown, or less than annual tax credit shown?

☐ Receive annual tax credit shown
☐ Receive more
☐ Receive less

[Group B2: WTA CONTINGENT VALUATION version]

If the status quo scenario is implemented, how effective do you think it will be at conserving the Saskatchewan River Delta over the next 20 years?

Extremely Effective Very Effective Moderately Effective Slightly Effective Not Effective at All

☐ ☐ ☐ ☐ ☐

Did you believe that if the alternative scenario is implemented, you and your family would be paid an annual tax credit of [$BIDAMT] for the next 20 years, more than [$BIDAMT], or less than [$BIDAMT]?

☐ Receive [$BIDAMT]
☐ Receive more
☐ Receive less

[All survey versions]

Conservation actions often have uncertain impacts on the environment.

Some conservation actions have greater certainty over the environmental outcome, but result in smaller changes.

Other conservation actions have more uncertainty over environmental outcomes, but have the chance of resulting in larger changes.

18. Suppose the government is choosing between two conservation projects that aim to increase the waterfowl population in the Saskatchewan River Delta.
    Which project would you prefer the government implement?

___Project A: Certain to increase the waterfowl population by 100,000 breeding ducks.

___Project B: A 50% chance of increasing the waterfowl population by 200,000 breeding ducks and a 50% chance of resulting in no change in waterfowl population numbers.

19. Now suppose the government is choosing between allowing two upstream projects that will decrease the waterfowl populations in the Saskatchewan River Delta.
    Which project would you prefer the government implement?

___Project C: Certain to decrease the waterfowl population by 100,000 breeding ducks.

___Project D: A 50% chance of decreasing the waterfowl population by 200,000 breeding ducks and a 50% chance of resulting in no change in waterfowl population numbers.

20. We would like to understand what factors may or may not have influenced your responses to earlier questions. Below is a list of statements people have made in similar surveys about why they responded as they did.

How much do you agree or disagree with each of the following statements?

[Randomize statement orders]

	Strongly Agree	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**
I had enough information to make an informed choice.					
Information in the survey was easy to understand.					

I do not trust the government to conserve the delta.					
I did not consider selecting the Status Quo alternative in making my choices.					
It is important to conserve the delta, no matter how much it costs.					
The added cost I am willing to pay is to protect the environment in general and not just to protect the delta.					

21. Thinking about the choices you have just made, please rate how much you agree or disagree with each of the following statements

[Randomize statement orders]

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
My choices would have been different if the economy in my area were better.					
With the COVID-19 pandemic, I think my priority of spending my money has changed.					
I do not think I should have to contribute to the conservation of the delta.					
I do not believe that the alternative conservation scenarios are actually feasible.					

The delta is too far away from my home for me to actually care.					

[Next question is for Group A1 or A2 only]

[Programmer's note: Only present the next question to respondents who choose the Status Quo option at least once]

22. If you voted for Status Quo, please rate how much you agree or disagree with each of the following statements

	Strongly Agree	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**
I voted for the Status Quo because I am against any more taxes or government spending.					
I would not vote for the conservation programs even if there were no added costs to my household.					
I voted for the Status Quo alternative because I believe my taxes are already too high.					

23. How important to you are the following benefits from natural areas in Canada?

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Support the traditions, livelihoods and culture of Indigenous peoples					
Being able to eat fish and animals that have been caught in the wild					

Support tourism and provide local communities with jobs

Being able to see wildlife when in nature

Knowing that a large diverse range of plants and animals exist in Canada, even if I never see them

24. During the past 12 months, how much money in total did you spend on donations or membership fees to nature or conservation organization? *(This includes groups at the local, regional, national, or international level. If you did not spend any money, enter "0")*

$CDN ____

25. Do you consider that the amount of income tax you pay is...?

___Too high

___About right

___Too low

___Don't know

26. Please think back about everything you read during this survey. Overall, do you think it tried to push you to choose one way or the other, or let you make up your own mind about how to choose?

☐ Tried to push you to choose the Status Quo option

☐ *[If A1 or B1]* Tried to push you to choose the Alternative A or B options

☐ *[If A2 or B2]* Tried to push you to choose the Alternative A option

☐ Let me make up my own mind

There are different ways for people to pay for new programs to protect the environment. One way is for the government to pay the cost. This will raise everyone's taxes. The other way is for businesses to pay the cost. This will make prices go up for everyone.

27. If you had to choose, would you prefer to pay for new environmental programs through higher taxes, or through higher prices?

__ Higher Taxes

__ Higher Prices

__ Either one, I don’t care which

28. Would you say that you think of yourself as:

__ A very strong environmentalist

__ A strong environmentalist

__ A moderate environmentalist

__ Slightly an environmentalist

__ Not an environmentalist at all

29. When it is safe to travel, would you like to visit the Saskatchewan River Delta?

__Yes

__No

__ Don’t Know

This information is for statistical purposes only – to help us better understand your answers. Remember that responses are confidential.

30. How many individuals live in your household (including yourself)?

______

31. How many children under the age of 18 live in your house?

______

32. Which gender do you prefer to identify with?

___Man

___Woman

___Gender non-binary/third gender/other

____Prefer not to say

33. What is your birth year?

______

34. What is the first 3 digits of your postal code?

______

35. Did you or your parents immigrate to Canada from another country?

___ Yes

___ No

36. To the best of your knowledge, the total household income from all sources before tax falls into which of the following:

$0-$9,999

$10000-$29999

$30000-$49999

$50000-$69999

$70000-$89999

$90000-$124999

$125000-$149999

$150000-$174999

$175000-199999

Over $200,000

Prefer not to say

37. What is the highest level of education that you have completed?

____Less than high school

____High school graduate

____Vocational/Trade/Technical School

____Some University/College

____Bachelor’s degree

____Advanced degree

38. Which of the following categories best describes your current employment status?

_____Employed full time

_____Employed part time

_____Student

_____Retired

_____Full-time homemaker

_____Unemployed

39. If a federal election were held today, how would you vote federally? Please select one response only.

___Conservative

___Green

___Liberal

___New Democratic

___Bloc Quebecois

___Other

___Not Eligible to Vote

___I would not Vote

___Prefer not to say

40. Has any members of your household received income support or lost their employment due to COVID-19?

____Yes

____No

[If Yes to previous question, present this question]

41. Please think about three months from now, how likely do you think is that the person impacted will be employed at that time?

Very likely	Somewhat likely	Somewhat unlikely	Very unlikely
☐	☐	☐	☐

Thank you very much for taking the time to answer the questionnaire.

42. Please enter any additional comments you may have about this survey in the space provided.

Appendix B – Econometric Models Run but not Included in the Main Analysis

Table B-1 MNL model with yea-sayers excluded

```
Model name                      : model
Model description               : No model description provided in apollo_control
Model run at                    : 2022-03-31 09:22:41
Estimation method               : bfgs
Model diagnosis                 : successful convergence
Number of individuals           : 948
Number of rows in database      : 5688
Number of modelled outcomes     : 5688

Number of cores used            :  1
Model without mixing

LL(start)                       : -6248.91
LL(0)                           : -6248.91
LL(C)                           : -6173.75
LL(final)                       : -5796.23
Rho-square (0)                  :  0.0724
Adj.Rho-square (0)              :  0.0715
Rho-square (C)                  :  0.0611
Adj.Rho-square (C)              :  0.0602
AIC                             :  11604.47
BIC                             :  11644.34

Estimated parameters            :  6
Time taken (hh:mm:ss)           :  00:00:2.96
     pre-estimation             :  00:00:0.82
     estimation                 :  00:00:0.72
     post-estimation            :  00:00:1.43
Iterations                      :  13
Min abs eigenvalue of Hessian   :  472.9327

Unconstrained optimisation.

Estimates:
                Estimate        s.e.   t.rat.(0)    Rob.s.e. Rob.t.rat.(0)
b_statusquo    -0.181295     0.04598      -3.943     0.07306        -2.482
b_aprice       -0.004081  1.7713e-04     -23.037  2.5934e-04       -15.734
b_afish         0.007146  5.0632e-04      14.113  5.4257e-04        13.170
b_awaterfowl    0.006624  6.1810e-04      10.716  6.2179e-04        10.653
b_amuskrat      0.006007  6.5354e-04       9.191  6.8856e-04         8.724
b_awetland      0.009163  7.7185e-04      11.871  8.1883e-04        11.190
```

Table B-2 MNL model with protest responses excluded

```
Model name                       : NOPROTESTMnl
Model description                : No model description provided in apollo_control
Model run at                     : 2022-04-04 13:22:06
Estimation method                : bfgs
Model diagnosis                  : successful convergence
Number of individuals            : 941
Number of rows in database       : 5646
Number of modelled outcomes      : 5646

Number of cores used             :  1
Model without mixing

LL(start)                        : -6202.76
LL(0)                            : -6202.76
LL(C)                            : -6085.01
LL(final)                        : -5739.91
Rho-square (0)                   :  0.0746
Adj.Rho-square (0)               :  0.0737
Rho-square (C)                   :  0.0567
Adj.Rho-square (C)               :  0.0557
AIC                              :  11491.81
BIC                              :  11531.65

Estimated parameters             :  6
Time taken (hh:mm:ss)            :  00:00:2.77
     pre-estimation              :  00:00:0.81
     estimation                  :  00:00:0.77
     post-estimation             :  00:00:1.19
Iterations                       :  14
Min abs eigenvalue of Hessian    :  498.05

Unconstrained optimisation.

Estimates:
                Estimate        s.e.   t.rat.(0)    Rob.s.e. Rob.t.rat.(0)
b_statusquo    -0.275491     0.04481      -6.148     0.06894        -3.996
b_aprice       -0.003782  1.7252e-04     -21.923  2.5696e-04       -14.718
b_afish         0.006941  4.9604e-04      13.994  5.2884e-04        13.126
b_awaterfowl    0.006546  6.0944e-04      10.740  6.0379e-04        10.841
b_amuskrat      0.006134  6.4332e-04       9.536  6.7466e-04         9.093
b_awetland      0.008722  7.5570e-04      11.542  8.0058e-04        10.895
```

Table B-3 Latent class model – 3 class model (not included in the main analysis)

```
Maximum Likelihood estimation
BFGS maximization, 6 iterations
Return code 0: successful convergence
Log-Likelihood: -4488.796
32  free parameters
Estimates:
                       Estimate Std. error t value  Pr(> t)
b_statusquo_1          2.996611   0.338154   8.862  < 2e-16 ***
b_aprice_1            -0.489661   0.149252  -3.281 0.001035 **
b_afish_1              0.009683   0.003789   2.555 0.010609 *
b_amuskrat_1          -0.002595   0.004800  -0.541 0.588767
b_awaterfowl_1         0.010213   0.004396   2.323 0.020174 *
b_awetland_1          -0.003037   0.005941  -0.511 0.609220
b_statusquo_2         -1.839439   0.198785  -9.253  < 2e-16 ***
b_aprice_2             0.118710   0.042148   2.816 0.004855 **
b_afish_2              0.009717   0.001067   9.109  < 2e-16 ***
b_amuskrat_2           0.006326   0.001139   5.554 2.79e-08 ***
b_awaterfowl_2         0.007216   0.001139   6.338 2.33e-10 ***
b_awetland_2           0.014233   0.001514   9.401  < 2e-16 ***
b_statusquo_3         -1.569124   0.104067 -15.078  < 2e-16 ***
b_aprice_3            -1.254285   0.086886 -14.436  < 2e-16 ***
b_afish_3              0.007206   0.001040   6.932 4.16e-12 ***
b_amuskrat_3           0.008294   0.001272   6.518 7.11e-11 ***
b_awaterfowl_3         0.008565   0.001262   6.790 1.12e-11 ***
b_awetland_3           0.009245   0.001637   5.646 1.64e-08 ***
d_constant_2          -0.139728   0.275846  -0.507 0.612474
d_constant_3           0.396930   0.263492   1.506 0.131959
d_Male                 0.255803   0.194764   1.313 0.189048
d_employed            -0.036025   0.220772  -0.163 0.870381
d_prairies            -0.634662   0.234629  -2.705 0.006831 **
d_highincome           0.296113   0.213383   1.388 0.165227
d_universityeducation  0.673044   0.202616   3.322 0.000894 ***
d_oldergroup           0.468077   0.212721   2.200 0.027777 *
d_Male1               -0.258584   0.187548  -1.379 0.167968
d_employed1            0.223618   0.212738   1.051 0.293193
d_prairies1            0.024130   0.205181   0.118 0.906384
d_highincome1          0.229871   0.205701   1.117 0.263781
d_universityeducation1 0.302231   0.193378   1.563 0.118074
d_oldergroup1          0.266752   0.202660   1.316 0.188089
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
--------------------------------------------
```

Table B-4 Latent class model – 4 class model (not included in the main analysis)

```
Model name                        : LCM4CSD
Model description                 : 4-class LCM
Model run at                      : 2022-03-11 02:28:17
Estimation method                 : bfgs
Model diagnosis                   : successful convergence
Number of individuals             : 965
Number of rows in database        : 5790
Number of modelled outcomes       : 28950
                          Class_1 : 5790
                          Class_2 : 5790
                          Class_3 : 5790
                          Class_4 : 5790
                            model : 5790

Number of cores used              :  5
Model without mixing

LL(start)                         : -8545.85
LL(0, whole model)                : -6360.97
LL(C, whole model)                : -6277.09
LL(final, whole model)            : -4797.83
Rho-square (0)                    :  0.2457
Adj.Rho-square (0)                :  0.2387
Rho-square (C)                    :  0.2357
Adj.Rho-square (C)                :  0.2285
AIC                               :  9685.66
BIC                               :  10057.96
```

Estimates:

	Estimate	Std.err.	t.ratio(0)	Rob.std.err.	Rob.t.ratio(0)
b_statusquo_1	3.1250	Inf	0	NaN	NaN
b_aprice_1	-0.0047	Inf	0	NaN	NaN
b_afish_1	1.0547	Inf	0	NaN	NaN
b_amuskrat_1	-0.2554	Inf	0	NaN	NaN
b_awaterfowl_1	1.0811	Inf	0	NaN	NaN
b_awetland_1	-0.2428	Inf	0	NaN	NaN
b_statusquo_2	-1.5659	Inf	0	NaN	NaN
b_aprice_2	-0.0135	Inf	0	NaN	NaN
b_afish_2	0.6615	Inf	0	NaN	NaN
b_amuskrat_2	0.8210	Inf	0	NaN	NaN
b_awaterfowl_2	0.8676	Inf	0	NaN	NaN
b_awetland_2	0.8275	Inf	0	NaN	NaN
b_statusquo_3	-1.8579	Inf	0	NaN	NaN
b_aprice_3	-0.0003	Inf	0	NaN	NaN
b_afish_3	1.0700	Inf	0	NaN	NaN
b_amuskrat_3	0.7273	Inf	0	NaN	NaN
b_awaterfowl_3	0.7855	Inf	0	NaN	NaN
b_awetland_3	1.5311	Inf	0	NaN	NaN
b_statusquo_4	-4.0010	Inf	0	NaN	NaN
b_aprice_4	3.0966	Inf	0	NaN	NaN
b_afish_4	72.4265	Inf	0	NaN	NaN
b_amuskrat_4	-38.2376	Inf	0	NaN	NaN
b_awaterfowl_4	67.3478	Inf	0	NaN	NaN
b_awetland_4	79.6678	Inf	0	NaN	NaN
d_constant_2	0.5873	Inf	0	NaN	NaN
d_constant_3	0.7580	Inf	0	NaN	NaN
d_constant_4	-2.3099	Inf	0	NaN	NaN
d_age	0.1020	Inf	0	NaN	NaN
d_gender	0.1768	Inf	0	NaN	NaN
d_province	-0.0029	Inf	0	NaN	NaN
d_income	-0.0513	Inf	0	NaN	NaN
d_employment	-0.1485	Inf	0	NaN	NaN
d_visit	0.1088	Inf	0	NaN	NaN
d_knowledge	-0.0306	Inf	0	NaN	NaN
d_age2	0.1957	Inf	0	NaN	NaN
d_gender2	-0.0695	Inf	0	NaN	NaN
d_province2	0.0012	Inf	0	NaN	NaN
d_income2	-0.0373	Inf	0	NaN	NaN
d_employment2	-0.1083	Inf	0	NaN	NaN
d_visit2	-0.1193	Inf	0	NaN	NaN
d_knowledge2	-0.0771	Inf	0	NaN	NaN
d_age3	0.4122	Inf	0	NaN	NaN
d_gender3	-1.4940	Inf	0	NaN	NaN
d_province3	0.0590	Inf	0	NaN	NaN
d_income3	-0.1358	Inf	0	NaN	NaN
d_employment3	-0.4421	Inf	0	NaN	NaN
d_visit3	0.6701	Inf	0	NaN	NaN
d_knowledge3	0.4226	Inf	0	NaN	NaN

Table B-5 Log-linear MNL model (used to calculate contingent valuation)

```
LL(start)                       : -6360.97
LL(0)                           : -6360.97
LL(C)                           : -6277.09
LL(final)                       : -5926
Rho-square (0)                  :  0.0684
Adj.Rho-square (0)              :  0.0674
Rho-square (C)                  :  0.0559
Adj.Rho-square (C)              :  0.055
AIC                             :  11864
BIC                             :  11903.98

Estimated parameters            :  6
Time taken (hh:mm:ss)           :  00:00:3.45
     pre-estimation             :  00:00:0.84
     estimation                 :  00:00:0.86
     post-estimation            :  00:00:1.76
Iterations                      :  14
Min abs eigenvalue of Hessian   :  422.0458

Unconstrained optimisation.
```

Estimates:

	Estimate	s.e.	t.rat.(0)	Rob.s.e.	Rob.t.rat.(0)
b_statusquo	-0.291659	0.04441	-6.568	0.06939	-4.203
b_aprice	-0.004126	1.7866e-04	-23.094	2.6123e-04	-15.795
b_afish	0.316975	0.02116	14.978	0.02249	14.096
b_awaterfowl	0.306962	0.02617	11.727	0.02675	11.474
b_amuskrat	0.169606	0.01706	9.944	0.01817	9.333
b_awetland	0.497185	0.04119	12.072	0.04439	11.199

Appendix C – Behavioural Research Ethics Board Certificate of Approval

UNIVERSITY OF SASKATCHEWAN

Behavioural Research Ethics Board (Beh-REB) 11-Feb-2021

Certificate of Approval

Application ID: 2507

Principal Investigator: Patrick Lloyd-Smith

Department: Department of Agricultural and Resource Economics

Locations Where Research Activities are Conducted: Online, Canada

Student(s): Elisabeta Lika

Funder(s): Social Sciences and Humanities Research Council of Canada

Sponsor: Social Sciences and Humanities Research Council of Canada

Title: Conserving the Saskatchewan River Delta

Approved On: 11-Feb-2021

Expiry Date: 11-Feb-2022

Approval Of: Behavioural Application Form

Focus Group Consent Form

Focus Group Script

Draft Survey

Acknowledgment Of:

Review Type: Delegated Review

CERTIFICATION

The University of Saskatchewan Behavioural Research Ethics Board (Beh-REB) is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TPCS 2 2018). The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this project, and for ensuring that the authorized project is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month prior to the current expiry date each year the project remains open, and upon project completion. Please refer to the following website for further instructions: https://vpresearch.usask.ca/researchers/forms.php.

Digitally Approved by Patricia Simonson
Vice-Chair, Behavioural Research Ethics Board
University of Saskatchewan

Appendix D – Responses of the whole sample to debriefing questions used to identify protest responses and yea-sayers

Table D-1 Responses of the whole sample to debriefing questions

Debriefing Questions	**Likert Scale Response Options**				
Questions used to identify protest responses[34]					
	Strongly Agree	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**
I voted for the Status Quo because I am against any more taxes or government spending.	10%	14%	15%	7%	2%
I would not vote for the conservation programs even if there were no added costs to my household.	3%	7%	15%	13%	12%
I voted for the Status Quo alternative because I believe my taxes are already too high.	12%	15%	14%	5%	2%
Questions used to identify yea-sayers					
	Strongly Agree	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**
It is important to conserve the delta, no matter how much it costs.	17%	36%	33%	11%	3%
The added cost I am willing to pay is to protect the environment in general and not just to protect the delta.	19%	46%	26%	6%	3%

[34] Percentages do not add up to 100% because of respondents that chose not to answer this question.