VALUES OF ECOLOGICAL GOODS AND SERVICES PROVIDED BY WETLAND FOR POLICY DEVELOPMENT IN SASKATCHEWAN

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ABSTRACT

The economic integration between natural and managed ecosystem is a growing area of interest to agricultural policy makers. The complexity of such integration has many different implications for the development of appropriate policy. Often, management of wetland resources located on private land involves a perceived conflict between social and private interests since landowners usually cannot benefit economically from wetlands on site unless they convert them to alternative uses such as agricultural crops. In general it has been shown that the market will undersupply public goods and/or oversupply public bads, and that often public organizations (e.g. government) have a role to ensure the provision of public goods, such as many categories of ecological goods and services (EG&S).

The development of effective policy to ensure efficient provision of EG&S is hampered by a poor understanding of the preferences and values of EG&S held by farmers and society. Thus, the present work proposes the investigation of the preferences of society with respect to EG&S provision in the province of Saskatchewan. Using data from a survey of Saskatchewan residents, the willingness to pay (WTP) for wetland attributes was quantified. In addition, participant's perceived share of conservation responsibilities were assessed. As indicated by the results from two logit models that were developed based on survey responses, respondents felt that all of the wetland management attributes are significant factors in the choice of a wetland management scenario, and *ceteris paribus*, higher levels of any single attribute increases the probability that a management scenario is selected. In other words, respondents prefer those wetland management scenarios which result in higher levels of riparian area, wildlife population and water quality. Indeed, the results from management scenarios presented in this study suggest that when considering wetland preservation in Saskatchewan agricultural areas, participants would most likely prefer policies that provide water quality. Overall, this study is expected to inform policy makers of society's preferences towards EG&S provision in Saskatchewan.

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1. CHAPTER – INTRODUCTION

Ecosystem management is an area of study area that has been receiving growing interest. Particularly, the complexity of the physical interactions that allows marketed and non-marketed goods being jointly produced has been challenging policy makers recently. However, the argument that public policy needs to address issues of public goods under-provision is not new. There is a long history of research that identifies the need for public provision or public intervention through appropriate policy instruments when considering the private or market provision of goods and services that have the characteristics of public goods.

Within economics, the concept that is often used to capture the joint production of market or private goods such as agricultural commodities and public goods and services such as ecological goods and services (EG&S) is the concept of externality. An externality is understood as an impact, positive or negative, on any party not directly involved in the economic decision. In other words, an externality exists when an economic activity causes external costs or benefits to a third party who cannot directly affect the economic transaction or resource use decisions. Therefore, in the present context, from agricultural production of a private good, the degradation or provision of EG&S can be considered externalities that are absorbed by society (the third party). For example, the generation of biodiversity from native range used for grazing cattle could be considered an external benefit from the private decision of the landowner to maintain the parcel of land in native cover. The presence of externalities in a market based economy suggests market failure. From this, some questions are naturally raised, such as: how can a market failure be corrected? If there is a negative externality, who should bear its cost? Similarly, if there are social benefits being produced, should society pay for these? How much would society be willing to pay or how much would farmers be willing to accept to adopt management practices that influence the generation of those externalities?

One of the primary economic issues associated with the provision of EG&S is the fact that by leaving the market unaffected by policy, many EG&S will tend to be undersupplied from a

social welfare perspective thereby resulting in inefficient resource allocation. In a foundational paper on the allocation of resources, Coase (1960) describes the economic efficiency of resource allocation or outcome in the presence of externality. From that work originated the Coase theorem which states that when trade in an externality is positive and there are no transaction costs, bargaining will lead to an efficient outcome regardless of the initial allocation of property rights. More recently, Baliga and Maskin (2003) argue that an allocation that maximizes the benefits to all of society will not come about without government intervention when the externality is non-excludable (where a pure public EG&S can be an example). In general it has been shown that the market will undersupply public goods and/or oversupply public bads, and that often public organizations (e.g. government) are required to ensure the provision of public goods, such as many categories of EG&S.

Intervention by government within agroecosystems can be made in many different ways. Broadly, the policy tools available can be categorized according to the degree to which a farmer's participation is voluntary, to the role of government, and to the nature of the land management decision targeted (Claassen *et al.*, 2001). In a voluntary program, farmers receive incentives to adopt environmentally sound production practices, or disincentives to using environmentally damaging management, such as technical assistance, subsidy and tax programs. On the other hand, regulations are considered involuntary programs. Claassen *et al.* (2001) highlight that producer participation in environmental programs that have been used in the U.S. have mostly been voluntary. The role of government extends from information provider (*e.g.* education and technical assistance programs) to stabilising standards, monitoring and enforcement (*e.g.* regulatory programs). The three main categories of policy measures in this context are: I) information dissemination tools (*e.g.* educational and technical assistance programs); II) economic incentive tools (*e.g.* land retirement payment, market-based instruments, environmental taxes), and; III) regulation (*e.g.* environmental law). Information dissemination and regulation are beyond the scope of this thesis while economic incentive tools will be covered in more detail.

Economic incentive-based policies can provide positive incentives (such as "green-payment" to farmers and land retirement) designed to encourage the provision of positive externalities, or decrease the generation of negative incentives (such as input taxes and cost share policies) designed to discourage negative externalities. According to Claassen *et al.* (2001),

economic incentive instruments allow producers greater flexibility of response than regulatory approaches, as follows:

> *"Producers are free to weigh the incentive (subsidy or tax) against the costs they will encounter in making land use, management, or conservation practice changes that could increase a total subsidy payment or decrease a tax bill. Some producers may find it advantageous to forgo subsidies or pay a tax because the cost of making changes is high. Other producers may make large changes in response to the incentive. In this way, incentives can direct agri-environmental activity toward producers who can make changes (achieve gains) at the lowest cost. Hence, economists frequently hail incentive-based policies as efficient tools for environmental goals. Whether they are, in fact, efficient will depend on the agri-environmental setting and the details of the program design".*(Claassen et al. 2001).

One of pioneer incentive-based policy approaches to reduce negative externalities is known as Pigouvian taxes. Named after economist Arthur Pigou, these taxes were mainly used to correct the negativity externalities of a market activity. Thus, a Pigouvian tax is, for example, "*a tax levied upon each unit of pollution in an amount just equal to the marginal damage it inflicts upon society at the efficient level of output.*" (Katz and Rosen, 1991). Therefore, within the economic model the tax would cause an increase in the private cost of using the input that is taxed or on releasing the output that is taxed. Facing this increased cost (cost of production), the farmer has an incentive to decrease the quantity of that input or the quantity of the output and thereby decrease the costs to society of the particular production activity. For example, a tax on nitrogen fertilizer would increase the costs of using that production input resulting in management changes that decrease the quantity of nitrogen fertilizer used and/or adopt management that uses nitrogen more efficiently. This can potentially result in smaller nitrogen loads in runoff and surface and ground water, which can impose significant environmental cost.

Another example of incentive-based policy is a payment made to landowners responsible for positive externalities production. There are many different ways to provide incentives for positive externalities production such as subsidies, payments for land retirement, conservation payments and others. For example, payments provided to landowners to convert erodible land to some form of perennial vegetative cover can increase carbon sequestration services of the soil and wildlife habitat benefits of the land while also decreasing costs associated with soil erosion and nutrient runoff. According to the OECD (2006), subsidies are a very common form of agri-environmental policy in many jurisdictions.

One of the concerns with developing effective incentive-based policy is the problem of asymmetric information. According to Latacz-Lohmann and Van der Hamsvoort (1997), farmers

know better than policy makers about how participation in incentive-based program will affect their production plans and profit. Likewise, landholders may know little about government priorities, societal preferences and how this information might influence subsequent contracts (Stoneham *et al.,* 2003). Thus, the recommendation of a cost-effectiveness policy to provide EG&S is often difficult to policy makers. The design of a policy, its efficiency and viability can vary significantly from one situation to another (Klemperer, 2002; Claassen *et al.,* 2001). Therefore, the success of specific environmental policy does not ensure success in other contexts. For example, society may have different preferences, the impact (positive or negative) of EG&S on society may vary across space and time, the productivity of the land in terms of environmental outputs and/or agricultural commodities will also influence different costs and priorities of policy.

The development of effective policy to ensure efficient provision of EG&S is hampered by a poor understanding of the preferences and values of EG&S held by farmers and society. Trying to establish a policy to ensure efficient provision of EG&S, the present work proposes the investigation of the preferences of society with respect to EG&S provision in the province of Saskatchewan[1]. If it is assumed that the provision of EG&S will be, at least partly, paid for by society through incentive-based policy measures, it is important to understand the preferences of society with respect to EG&S.

1.1. The Problem

Saskatchewan has the largest area of agricultural land in Canada. Concern over the relationship between the production of agricultural commodities and the provision of EG&S from these same landscapes has been evident in different aspects of provincial and federal level agri-environmental policy in recent years. However, understanding the impact of these policies and the preferences of society on EG&S provision is somewhat limited.

[1] This study is limited to Saskatchewan due to the provincial government interest on the information necessary to develop effective policy to provide EG&S in agricultural landscape.

From the perspective of the policy maker, designing an efficient EG&S program is sometimes difficult. One of the main problems for policy makers is effectively understanding the preferences and values that farmers and society apply to those EG&Ss that do not have market value (public goods). From this perspective how much the government allocate resources to improving, for example, water quality is considered with relation of how much society values the increase in water quality. The problem here is how to exchange information of needs and interests between government, society and farmers in order to efficiently provide EG&S.

1.2. Research Objectives

The primary purpose of the present research is to help inform the development of effective policy to provide EG&S in the agricultural landscape of Saskatchewan. More specifically, from a Saskatchewan government policy perspective, this project is directed at understanding society's perspective on EG&S and how important the goods and services provided by agricultural landscapes are. This will help policy makers to understand whether government support of EG&S provision is supported by Saskatchewan taxpayers. The following research objectives will be addressed in informing the stated problem:

- Evaluate the preferences and choices over EG&S from Saskatchewan residents;
- Estimate the perceived level of environmental responsibility, between society and landowners, of providing EG&S on privately owned land;
- Assess EG&S policy and identify policy implications for Saskatchewan.

With the proposed objectives, the recommendation of a public policy focused on EG&S provision in Saskatchewan is an expected outcome.

1.3. Methods and Thesis Organization

As first step toward the development of this project, an assessment of EG&S policy measures in Canada and worldwide is provided. This was done primarily through a review of the relevant literature. Chapter 2 presents an overview of the status of EG&S functions and measurement techniques with a particular focus on wetlands within agricultural landscapes. The chapter begins with a brief introduction of EG&S functions, property right problem, public policies tools. The chapter concludes by providing an overview of the market and non-market valuation mechanisms for valuing wetlands.

The analytical framework utilized in this research is elaborated in chapter 3. In this chapter why a "market failure" may occur with respect to wetland outputs and how it would affect distribution of land use in privately owned agricultural landscape have been identified. With the help of a graphic model, the role of a financial incentive as a policy tool to encourage conservation of wetlands is examined as a solution to this problem.

A choice experiment was then used to determine values and trade-offs, with respect to specific categories of EG&S. For the purpose of the present research the EG&S relevant to the conservation of wetlands (e.g. water quality, wildlife habitat) was be the primary focus. The choice model was addressed using the survey instrument by asking respondents to indicate the proportion of the costs of EG&S provision should be provided by the landowner and the proportion that should be the responsibility of society through conservation payments. For better comprehension, this thesis is structured in the following manner. Chapter 4 contains the methodological information and the description of the survey adopted in the study.

Chapter 5 presents a description of the results for the empirical work for this analysis along with a discussion of significant variables. In this chapter it is shown how society perceive the level of responsibility for EG&S provided by wetland management and the amount of economic incentive society are willing to pay for them. The results have policy implications that are also discussed in chapter 5.

Lastly, chapter 6 summarizes the results of the thesis and offers the limitation of the study. Topics for future research are suggested.

2. CHAPTER – LITERATURE REVIEW

2.1.Introduction

The economic integration between natural and managed ecosystem is a growing area of interest to agricultural policy makers (Hodge, 2000). The complexity of such integration has many different implications for the development of appropriate policy. Economic theory has been challenged by the characterization of Ecological Goods and Services (EG&S), and especially, the role that society plays in the provision and consumption of such goods and services. When considering the private or market provision of goods and services that have the characteristics of public goods (e.g. non-rivalry and non-excludability which will be developed later in this discussion) there is a long history of research that identifies the need for public provision or public intervention through appropriate policy instruments.

One of the primary economic issues[2] associated with the provision of wetland goods and services is the fact that by leaving just to the market, many EG&S will tend to be undersupplied from a social welfare perspective thereby resulting in inefficient resource allocation. In general it has been shown that the market will undersupply public goods and/or oversupply public bads, and that often public organizations (e.g. government) are required to ensure the provision of public goods, such as many categories of EG&S (Hardin, 2009). Intervention by government within EG&S management can be made in many different ways (Claassen, *et al.*, 2001).

Despite some success, the recommendation of a cost-effectiveness wetland management policy remains a difficulty to policy makers. The design of a policy, its efficiency and viability can vary significantly from one situation to another (Claassen, *et al.*, 2001; Klemperer, 2002). Therefore, the success of specific environmental policy does not ensure success in other context.

[2] As discussed on the introductory chapter, an example of seminal work of process that leads into market failure and the need of institutional interference, see Coase (1960).

For example, society may have different preferences, the impact (positive or negative) of EG&S on society may vary across space and time, the productivity of the land in terms of environmental outputs and/or agricultural commodities will also influence different costs and priorities of policy. Thus, this chapter presents the background and issues relevant to the research objectives of this study. It is a general discussion of previous studies, literature, and types of programs and policies specific to the research problem.

2.2.Ecological Good & Services General Considerations

Economic theory classifies goods and services, and the capacity of those goods and services to be provided by markets, according to whether they exhibit the characteristics of rivalry and excludability (Romer, 1990, 1994). Excludability refers to the characteristic where individuals can be excluded from using or consuming the good which enables the producer to charge a fee to those who want to consume. For example, a farmer produces agricultural commodities (e.g. grain) with the knowledge that they can sell the commodity to a consumer, in exchange for a price, all other potential consumers can be excluded from using that commodity. Rivalry refers to the characteristic of goods and services where the use by one consumer is precluded by someone else or worded in another way, the use of a good or service by an individual makes less of the good or service available for other users. The combination of these two characteristics results in four types of goods: private good (rival and excludable); toll good (non-rival and excludable); common-pool good (rival and non-excludable), and; public good (non-rival and non-excludable). Within this classification among private good are crop products, livestock, and food in general; a very common example of toll good is the uncongested toll highway, where the addition of one car would not affect the traffic as a whole, and all drivers have to pay some toll; ocean fish, water, and hunting game can be examples of common-pool goods – in all these examples we consider a situation where there is no way to exclude others from consuming/doing the activity, but each one behaviour affect all – so if someone decides to harvest more fish, there will be less fish left to others. Finally, public goods can be clean air,

beautiful landscape, rivers, and quiet – all these examples cannot be assessed a toll for its use (there is no charge for those that want see a beautiful sunset on a landscape), and the number of people looking at the view does not affect others. Nevertheless, before classifying EG&S according to economic theory, it's important to understand more precisely what is meant by ecosystem functions and EG&S.

The demand for EG&S valuation to help inform development and policy decisions has experienced a significant increase in the past 10 to 15 years with a corresponding increase in research focused on the issue (Pearce, 1993; Turner, 1993; De Groot, 1992, 1994; Bingham *et al.*, 1995; Daily 1997; Costanza *et al.,* 1997; Pimentel & Wilson, 1997; Limburg & Folke, 1999; Wilson & Carpenter, 1999; Daily *et al.,* 2000; De Groot *et al.,* 2002). However, there is no exact boundary around the definition of EG&S and ecosystem functions which has caused some recent problems (De Groot *et al.,* 2002; Vikhlyaev, 2004; Claro *et al.,* 2007). EG&S have been mentioned in some of the most important international policy meetings around the world and it is a concept that is often still being interpreted differently from country to country (Claro *et al,* 2007). Such a situation indicates a necessity of being clear about the definition to be adopted by policy makers.

A definition for EG&S was proposed by De Groot (1992), which considers ecosystem functions as "the capacity of natural process to provide goods and services that satisfy human needs, directly or indirectly". According to this definition, ecosystem functions are best conceived as a sub-set of ecological processes and ecosystem structure. Each function is the result of natural process of the total ecological sub-system of which it is a part. A natural process, in turn, is the result of complex interactions between biotic and abiotic components of ecosystem through the universal driving forces of matter and energy.

Expanding this concept, De Groot *et al.* (2002) proposes a typology for the classification of ecosystem functions, goods and services. These authors suggest four groups of ecosystem functions (regulations, habitat, production and information) which, in turn, provide goods and services that are valued by humans. On the other hand, this classification limits the concept of goods and services to those that can be used on a sustainable[3] basis, in order to maintain the

[3] Those authors use the definition of sustainable proposed by De Groot *et al.* (2000): "the natural limits set by the carrying capacity of the natural environment (physically, chemically and biologically), so that human use does not irreversibly impair the integrity and proper functioning of its natural processes and components".

ecosystem functions and associated ecosystem processes and structures. This restriction excludes some natural mineral resources (gold, iron, diamonds and oil) and some energy sources (e.g. wind and solar-energy), and include some non-ecosystem specific functions (e.g. use of natural waterway for transportation) and some mineral sources that are removable within a time-frame of 100-1000 years (e.g. sand on beaches provided by dead coral and shells). In conclusion, De Groot *et al.* (2002) states that it's possible to arrive at a monetary estimation of human preferences for the availability and maintenance of the related ecosystem services. However, there is still a problem with his model which leads to the possibility of economically double-counting. To illustrate the overlapping problem, consider: gas-regulation functions (and associated services) have an influence on climate and can therefore be evaluated separately, or as an integral part of the climate regulation service (De Groot *et al.,* 2002). Therefore, the problem of overlapping resides in the interconnectedness of certain ecological functions.

For the propose of this thesis, the EG&S concept will rest on the Canadian definition[4] which consider EG&S as "goods and services that are used, or can potentially be used, to measure, prevent, limit or correct environmental damage (both natural or by human activity) to water, air, soil as well as problems related to waste, noise and ecosystem" (Statistics Canada, 2007). According to this definition, clean or resource-efficient ("eco-efficient") technologies that decrease material inputs, reduce energy consumption, recover valuable by-products, reduce emissions and/or minimize waste disposal problems are included within the definition for EG&S. This Canadian definition suggests a broader concept than the international one proposed by OECD/Eurostat. The main difference between them are in "or can potentially be used" and in the specification damage causes "both natural or by human activity". Statistic Canada (2007) highlights that the focus of the Canadian definition is on the end-use instead of the physical attributes of goods and services. This definition also address the question: "Does a particular good or service exist in the market either solely or partly because of its environmental components?".

[4] Unless it is clearly specified the opposite (e.g. EG&S by international/De Groot et al. definition).

2.3. EG&Ss provided by Wetlands

A wide range of EG&S can be produced by an agricultural landscape. Depending on land management practices, landowners have the ability to increase, hold steady, or decrease the level of EG&S production. Examples of EG&S that can be provided by agriculture include ground water recharge, flood and erosion control, carbon sequestration, biodiversity, and air and water purification. However, land use practices, in Canada, have served mainly for purpose of provisional services (i.e. food production), usually at the expense of environmental protection (Olewiler, 2004). Especially for Saskatchewan where EG&S provided by wetlands have been historically under-supplied in agricultural landscape.

Cortus (2005), for example, determined the economic feasibility of draining wetlands on farms in eastern Saskatchewan. From this study, it was found that a rational farm operator would drain wetland areas, rather than purchase new lands to expand his cultivated land base. The cost of purchasing land in the study area averaged around $640 per hectare, while the cost of draining wetlands was approximately $500 per hectare (Cortus, 2005). Thus, conducting drainage on existing lands was profitable to the farm operator. Wetland areas do not provide direct financial benefits to crop producers, so the incentive to convert wetlands can be considerable. Furthermore, Cortus (2005) argue that there may be a direct nuisance cost associate with maintaining wetlands, which make up approximately 35% of the benefits achieved from draining wetlands. More recently, studying the economics of wetland drainage and retention in Saskatchewan, Cortus *et al.* (2011) compared the private net benefits to existing estimates of the public benefits to retaining wetlands, and concluded that wetlands were still at risk of damage.

2.3.1. Wetland Ecological Functions

As discussed above EG&S represent the benefits that humans derive from ecosystem functions (Prairie Habitat Joint Venture, 2005; Costanza, *et al.*, 1997; Costanza, *et al.,* 1998). Wetlands fulfil a diverse number of functions that result from the interaction between the structural component (soil, flora, and fauna) and the physical, chemical, and biological processes (Seyam *et al.*, 2001). Many wetland functions are interdependent because one single process

influences more than one function. This basic understanding implies that the continuity of a single function is not separable from other functions; it depends on the maintenance of the integrity of the entire system (de Groot, 1992; Seyam *et al.*, 2001). Thus, a natural concern is how to decompose ecological systems into commodities that are both consistent with ecological science and meaningful to society (Carson & Mitchell, 1993).

Analogous to the standard production system, wetland attributes can also be thought as production functions transforming biophysical inputs into *ecological endpoints* (Boyd & Krupnick, 2009). Biophysical inputs are environmental features or conditions that are converted via natural processes into different environmental features or condition (Boyd & Krupnick, 2009). Ecological endpoints, however, are a subset of biophysical outputs that directly enter firm or home production, which require little or no subsequence biophysical translation in order to make the relevance to utility clear. Thus, ecological endpoints are things people experience, make choice about, and that have tangible meaning. For example, the dissolved oxygen level in water is not directly experienced, nor is it typically the subject of household choice, nor is it tangibly meaningful to most non-experts. But there are ecological endpoints that are dependent on dissolved oxygen as an input. Dissolved oxygen can affect fish populations and water clarity and odour, for example. These attributes are much more likely to be directly experienced, bear directly on households choices, or be identified as intuitively important to utility. Therefore, it can be described as ecological endpoints to a system involving dissolved oxygen (an input to the endpoints' production) (Boyd & Krupnick, 2009). Carson and Mitchell (1993) provide an example of the distinction between inputs and endpoints by translating numerical water quality measures that lack meaning to non-experts into non-technical categories such as "swimable", "fishable" and "boatable". Similarly, Bateman et al. (2005) convey the biological impacts and risks associated with increasing levels of acidity in a manner that can be linked to, but do not require presentation of pH levels, since pH levels are not meaningful to non-experts. There are many types of EG&S, which as presented by Swinton (2008), encompass four broad areas according to the services they provide, as determined by Milleniun Ecological Assessment (2005):

- "Provisioning services: include food, fibre, wood, fuel and fresh water that provide for human subsistence;

- Regulating services: maintain the balance of Earth's systems at levels that enables human survival. These services include climate, flood, water quality and disease regulation. Examples include vegetation that buffers the effect of natural flooding, or predator – prey systems that limit the spread of pathogens;
- Cultural services: include the spiritual, inspirational, aesthetic, heritage, recreational and tourism benefits;
- Supporting services: include the myriad natural systems that enable the three tiers above. For example, organic matter cycling contributes to soil creation, which makes food provision possible. Photosystensis transforms solar energy into plant matter, enabling provisioning services, carbon cycling, and various other services."

The types of EG&S that humans receive from wetlands or wildlife habitat are numerous and fall across each of the above categories. From these categories, many EG&S have been used especially in valuation studies, recently. However, the EG&S characterization for valuation studies has been the focus of some concerns. The section below introduces the EG&S characterization in valuation studies, which supports a more detailed discussion later in this chapter.

2.4. Market Failure and Wetland Valuation

2.4.1. Wetland valuation studies

For valuing wetlands, different frameworks are described in the literature. Roggeri (1995, cited by Seyam, *et al.,* 2001) for example distinguishes wetland resources, wetland attributes and physical/hydrological functions. However, none of the distinguished categories is exclusive and no one benefit is exclusive to one category (Seyam *et al.*, 2001). Whitten and Bennett (2005) argue that the attributes would be defined to describe the outcomes of alternative wetland management strategies. Bennett and Adamowicz (2001) further state that attributes must be

measurable, of significance to policy makers and easily communicable to the wider community in the survey format. An example of easily communicable characterization can be the ecological system approach which will be described in the next paragraph.

According to Boyd and Krupnick (2009), there are several advantages to the ecological system approach. First, subjects are not required to understand the ecological system in order for the analyst to achieve a comprehensive valuation of the wetland bundle. It doesn't matter if a subject knows nothing about wetlands and their relationship to water quality, since they aren't being asked to value that relationship. Instead, they are being asked to directly value water quality. Second, the interpretation of valuations no longer hinges on the information assumptions associated with the subjects. Third, estimation of the production functions' role in generating value is left to those who can make the estimation most accurately: experts, instead of less informed subjects. Finally, endpoints can be recomposed into endpoint bundles in order to clearly detect substitution and complementarities effects across the endpoints (Boyd & Krupnick, 2009).

However, EG&S are often provided by complex ecological process resulting in dual commodities, where some components of the ecological output can be input to other ecological process. For example, riparian area considered as wildlife habitat isn't necessarily an endpoint, since it can be an input to many ecological processes. However, it can be considered endpoint if described as, for example, "*land cover that is natural open space and thus a contribution to aesthetic, bequest, or recreational benefits*" (Boyd & Krupnick, 2009). Indeed, attributes encountered in environmental valuation problems may be highly correlated and not intrinsically separable (Holmes & Adamowicz, 2003). Furthermore, if two correlated attributes were treated as independent in a valuation experiment, respondents might become confused, reject the scenario, and fail to answer the question. Although some empirical studies indicate that treating correlated attributes as independent factors does not cause serious problems (Huber & McCann, 1982; Moore & Holbrook, 1990; cited by Holmes & Adamowicz, 2003), in general, this problem is best solved by selecting attributes that represent separable dimensions of the valuation problem (Holmes & Adamowicz, 2003). There is a wide range of EG&S characterization in the resource economics literature. For example, in a meta-analysis of wetland valuation studies, Brander *et al.* (2006) collected 215 value observations in 190 wetland valuation studies, which range from recreational fishing to climate stabilization or appreciation of uniqueness to

culture/heritage. The figure below presents some examples of commonly used EG&S in valuation studies. The x axis represent the frequency in which each of the EG&S is observed in different studies according to Brander *et al.* (2006).

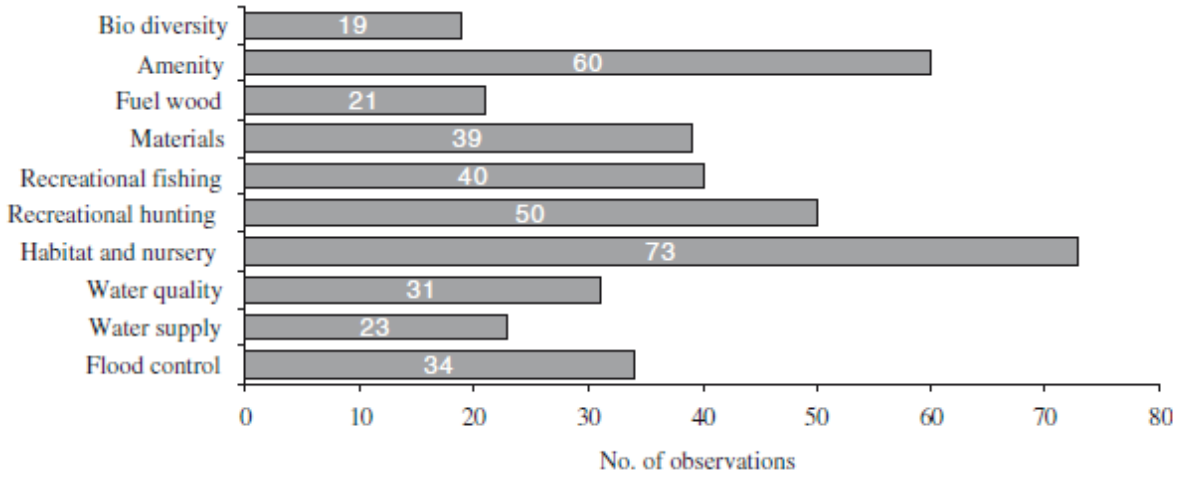


Figure 2.1. Number of observations for each wetland goods and services.

Source: adapted from Brander *et al.* (2006).

Among the wide range of EG&S provided by wetland, three of them are detailed below.

- Riparian area: those areas located immediately beside wetlands, streams and rivers. The riparian area can be measured according to the closest distance from the water surface to the agricultural land. Under the endpoint definition, riparian area (as explained earlier) can be considered a dual commodity (Boyd & Krupnick, 2009). However, many wetland valuation studies have considered riparian area as an attribute (see Do & Bennett, 2007; Carlsson, Frykblom & Liljenstolpe, 2003; Whitten & Bennett, 2005).
- Wildlife population: described as the abundance of wildlife species present in wetland, wildlife population can be considered an endpoint commodity (Boyd & Krupnick, 2009). The abundance of wildlife, such as fishes and ducks have also been identified as attributes in wetland valuation studies (Carlsson, Frykblom & Liljenstolpe, 2003; Whitten & Bennett, 2005; respectively). Wildlife population have also been considered in more general terms within biodiversity abundance by Birol *et al.,* (2006).

- Water quality: can be considered a dual commodity; however, it is an endpoint if described in such way that has direct relevance to households (Boyd & Krupnick, 2009). For example, the Boil Water Advisory, which is a public warning stating that the water supplied by a specific location may be unsafe for consumption. This means that prior to drinking, cooking, or even brushing your teeth, the water must be brought to a rolling boil for a specified amount of time.

As the examples demonstrate, attributes can be defined so that it is measurable and easily communicable. Furthermore, by representing separable dimensions (e.g. water quality and wildlife population) of the valuation problem, attributes can describe the outcomes of alternative wetland management strategies that are of significance to policy makers.

2.4.1.1. Water quality Rationality for Saskatchewanians

Water quality has long been a concern to Saskatchewan residents. According to the Saskatchewan Watershed Authority (SWA, 2010a), surface and ground water sources are vital for this province and a key driver for economic activities. Among the examples of services that water provides to Saskatchewan society, are: water supply for people, irrigation, livestock, and industry; maintenance of healthy environment; fish and wildlife habitat; hydropower generation; and recreational opportunities. However, as discussed earlier, the economically rational reaction for landowners is to drain their wetland and use the land for agricultural purposes (Cortus, 2005). In fact, many watersheds have been lost in Saskatchewan in the past. More recently, SWA (2010a) released a report informing that the majority of watersheds in agricultural Saskatchewan are at least under moderate intensity stress (66% of the total provincial watersheds).

In an attempt to address this situation and guarantee sustainable water supply for Saskatchewan society, provincial government through SWA is developing a $7.5 million multi-year project to ensure water supply information is available and understood to meet the economic needs of the province (SWA, 2010b). The provision of clean water is an issue of worldwide importance and the role of wetlands in providing water quality is increasingly recognized by society and policy makers in Saskatchewan. Thus, attributes measurements for goods and services related to water quantity and/or quality is expected to be relevant for both policy makers

and society in Saskatchewan (section 4.3.1 provide more detail about the water quality attribute used in this study).

2.4.2. Economic Valuation

From the policy maker perspective, designing an efficient EG&S program is sometimes difficult. One of the main problems for policy makers is understanding the preferences and values that farmers and society apply to those EG&S that do not have market value (public goods). Theoretically, in the context of the present discussion, this is a process to assign dollar values to goods and services provided by wetlands. In classical economics, the dollar value of a good is determined through the open market decided by the interaction of consumers demand and producers supply for the good. But this is not always possible for ecosystem goods and services since many such goods and services are complex and multifunctional (Barbier et al. 1997). The danger, if the '*unpriced*' value is not included in development decisions, is policy makers can not quantify the consequence of decisions and hence the final outcome of the policy will be biased in favour of those uses which have commercial value and many environmental resources cannot be properly conserved. Therefore, from agricultural production of a private good, EG&S degraded or generated can be external costs or benefits which is absorbed by society (the third party). The prevalence of externalities in a market based economy suggests the presence of market failure. Thus, in the present context, if a wetland is converted without proper valuation, the result can be a significant economic loss to society. Losses may include essential environmental functions as well as the biological values the wetland provides.

Olewiler (2004) argues that due to the loss of its natural areas, Canada is currently facing a crisis. According to Adamowicz (2007), such crisis has a negative impact on Canadian well-being, especially due to the depreciation of habitat, EG&Ss related to air, water quality and endangered species loss. But, Canadian governments are becoming increasingly aware of the need to protect natural capital. Olewiler (2007) lists five possible sources of problems to natural capital: i) lack of knowledge about our stocks and flows of natural capital and how much of it we need to protect; ii) the failure of markets to price nonmarket EGS; iii) competing priorities of governments; iv) financial constraints; v) insufficient long term planning by public decision-

makers. Therefore, increasing the understanding of societal preferences for EG&S can be used to help direct policies. Economic valuation for environmental resources such as wetlands play an important role when prevailing market valuation mechanisms don't effectively represent their environmental benefits. With the help of economic valuation, the competing uses of environmental resource can be effectively compared based on the trade-offs of resource allocation options to provide decision makers information that can directly inform conservation policies and increase the efficiency of resources management.

2.5. Level of responsibility for managing wetland

Following the debate of the importance of EG&S provision, and the development of policy measures to establish incentives for this provision, the question of who should be responsible for managing those resources, (or who should bear their costs) naturally arises. Examples of EG&S provided by prairie wetlands include groundwater recharge, flood and erosion control, carbon sequestration, biodiversity, and air and water purification. These EG&Ss represent benefits to people even if there is no consumptive monetary value for it. Whether it is the clean air they breathe, the clean water they drink, or the sight-seeing of wildlife they enjoy, people attach value to protecting and enhancing EG&S. For this reason, if property rights could easily be distinguished for an individual's clean air, the price he or she would be willing to pay would likely be substantial (Dollevoet, 2010). To reiterate and expand upon existing wetland policies, in Saskatchewan where wetland numbers are at a critical level to provide important ecological goods and services and are particularly vulnerable to climate change, policies must address the need for continued wetland protection (Johnson, *et al.*, 2005). Wetland policy will require an array of tools to meet social objectives; perhaps the most important consideration in choosing policy tools is how the costs will be distributed between farmers and society.

2.5.1. Property rights for wetland policy development

Property rights represent "*one individual's ability, in expected terms, to consume the goods or the services directly or to consume it indirectly through exchange*" (Barzel, 1997; cited by Whitten, 2003). That is, the stronger the property rights, the larger the proportion of the benefit stream the individual can access and potentially trade (Whitten, 2003). According to Kaplowitz (2000), when property rights are not well defined, conflict over the management of the environmental resources may occur. Generally, the conflicting parts have two distinct views. First, private landowners may claim that they hold the right to do as they wish with the resources on their land, which may result in Environmental degradation due to higher economic returns (e.g. crop production gains due to wetland drainage). Second, the public has a right to public environmental amenities derived from resources on private land and management decisions should be made in the context of socially acceptable behaviours.

The problem of these conflicting interests is exacerbated by the lack of properly defining the property rights. Benidickson (2002) argues that, in Canada, property rights aren't clearly protected by the *Charter of Rights and Freedoms*, or any constitutional provisions (despite existing implicitly). The problem generated by the lack of precise definition makes regulation of wetland management in a statutory framework very difficult. Therefore, the information provided by well-defined property rights can help design wetland policies.

2.6.Approaches to sustainable wetland policy development

Claassen *et al.* (2001) highlight that good sustainable policies are those that target funding to the areas where benefits are greatest relative to costs, allow producers the flexibility to meet environmental objectives and involve program co-ordination to avoid duplication and to offset the costs of each other. In the past, agri-environmental policies focused on pollution prevention; this focus gradually shifted to broaden the definition of environmental protection to ecosystem and landscape protection to ensure the provision of all ecological goods and services as opposed to targeting a single benefit (Claassen *et al.* 2001). While conceptually the ecosystem approach

has taken hold in society and with policy makers there is yet to be legislation passed that truly reflects the ecosystem approach (Cuddington, 2008). A variety of policy tools can be used to meet wetland conservation objectives ranging from voluntary to mandatory (Claassen, et al., 2001). The following section will provide details of the more common policy tools used to address environmental objectives.

2.6.1. Regulation

Regulation is a policy mechanism in which the participation option is involuntary. Rather than creating mechanisms to facilitate or encourage improvements in environmental performance, policy makers can simply require it. Policy makers can implement environmental regulation through a combination of statutory law, tort law and contractual law. Often, the provisions in these statutes for environmental protection are focused on environmental pollution, usually incorporating the "polluter pays" principle (Claassen, et al., 2001). For example, the ban on production and application of the chemical DDT is a regulation warranted when society's acceptable level of tolerance for environmental degradation is low. In fact, examples of regulation are often present in public health and safety concerns, in highly environmentally sensitive areas and where changes are irreversible in a short period of time as in the case of species extinction (Claassen, et al., 2001).

In regulatory policies, government agencies are usually responsible for establishing standards, monitoring and enforcing completion. Monitoring and enforcing standards can be difficult, particularly in agricultural landscapes where private land ownership dominates, and the number of landowners are usually high (Claassen, et al., 2001). For example, Saskatchewan has approximately 44,330 farms in an area of 26.02 million hectares (64.3 million acres) (Saskatchewan Ministry of Agriculture, 2006). Thus, monitoring and enforcing landowners across this area can be costly, especially if the policy mechanism requires landowners to be visited periodically. The difficulties of monitoring and enforcing agricultural landscapes where private land ownership dominates can also be verified for the Brazilian Forestall Code, which establishes that all water shed, river or lake within a farms must have at least 30 meters of riparian area, and each farm must allocate at least 20% of the total area for forest conservation

(called nature reserve). Such regulatory policy, for an extremely big area, can be so costly that monitoring and enforcing each property becomes nearly impossible, which is forcing the Brazilian government to review their Forestall Code[5]. Indeed, this type of program does not allow farmers the flexibility or freedom to opt out if management changes are too costly. Regulation is not only costly for taxpayers as the cost of establishing government standards, and then monitoring and enforcing them, but also for individuals forced to comply. Especially in the prairie agricultural region of Saskatchewan, where the vast majority of wetlands occur on private farm lands, a strictly regulatory approach to wetland protection would be unenforceable.

2.6.2. Land retirement and investment

Land retirement and (set aside) is a policy mechanism in which government agencies often purchase land for retirement. As one may suggest, this practise is feasible in some cases, but it also can be very costly for tracts of land. In fact, when agencies buy a crop land for retiring purposes the payments must cover the full value of the land in crop production (rather than the costs of modifying practices). Claassen, et al. (2001) argue that, in addition to the high cost of buying land, there may be resentment towards the government for competing against farmers in the market for land that is perceived to be suitable for agricultural production. Furthermore, this mechanism may not address environmental damages from the vast majority of croplands that remains in production. However, land retirement (e.g. wetland restoration) can provide habitat that increases wildlife populations, enhancing wildlife viewing, fishing, and hunting. Participation is this mechanism is voluntary, which gives more flexibility.

Land retirement programs are particularly well suited for securing environmental benefits that increase with the length of time land is removed from crop production. For example, wildlife habitat in wetland areas might have the ecosystem fully established after years of land retirement. Retirement programs may also be suitable for areas that are not sustainably farmed, such as steep slopes in valleys (Claassen, et al., 2001).

Often, a conservation easement represents a legal agreement between a landowner and a qualified conservation agency that tend to runs for long periods. For Saskatchewan, Ducks

[5] In the time that this study was written, the Brazilian Forestall Code was under revision.

Unlimited Canada, Nature Conservancy of Canada and Nature Saskatchewan are some of the agencies that are able to hold conservation easements (Government of Saskatchewan, 2011). Land owners may also opt for a perpetual easement in which case the natural values of the property would remain protected indefinitely, independently if the land is sold in the future (the easement would be transferred with the property). In Canada, the donation of a conservation easement may also be viewed as charitable gift by Canada Revenue Agency. The value of the gift is the appraised difference between the land's value with the conservation easement and the best land-use value without the easement. This taxable benefit may be observed at the time of donation or extended over five years (Government of Saskatchewan, 2011).

2.6.3. Economic incentives for wetland sustainable development

Economics incentives for sustainable development are policy mechanisms that enable or motivate improvement in behaviour. Participation in this mechanism is voluntary, which brings flexibility, since they allow farmers to weigh the costs and the benefits before they choose to participate in the program, and with lower costs of monitoring and enforcing. In fact, many economic incentives programs are designed to have a virtually zero costs of monitoring and enforcements. For example, the Australian Bush Tender requires that farmers show (prove) their actions with pictures in order to receive the payment, nevertheless; a non-noticed visit can happen (DSE, 2008). Despite the advantages, the efficiency of the program is greatly influenced by the program design and the payment mechanism and amount. Claassen, et al. (2001) suggest that an effective conservation program may be a combination of economic incentive instruments. Thus, no single policy instrument will be effective on its own. In terms of wetland policy in Saskatchewan perhaps a combination of compliance and economic incentive programs will be the best way of establishing farmers' obligations and rights.

While incentive instruments represent useful tools to increase ecosystem goods and service provision on private land, it is difficult to estimate efficient monetary values for economic incentive-based policies. Section 2.7 explores some of the economic tools for estimating monetary values for EG&S.

2.7.Economic valuation for wetland

Economic valuation can be perceived as an attempt to assign quantitative values to goods and services provided by environmental resources, whether or not market prices are available to assist. According to Barbier *et al.* (1997), economic valuation is one element "*in the effort to improve management of environmental resources such as wetland*". Therefore, assigning quantitative values may help wetland management. More specifically, the objective of valuation in assisting wetland management decisions is generally to indicate the overall economic efficiency of the various competing uses of wetland resources (Barbier, Acreman, & Knowler, 1997). There are many mechanisms for valuing EG&Ss, which can be grouped according to whether there is a market mechanism to assist the valuation method. Some of the commonly used valuation techniques are presented in the next sections.

2.7.1. Market mechanism

Many ecological goods and services have an established possibility of being traded. Among the examples of market mechanisms for ecological goods and services, are wetland mitigation banking; fee hunting; carbon market. However, often the presence of a market mechanism does not ensure proper provision or conservation of EG&Ss (Pagiola, Landell-Mills, & Bishop, 2002). Some of the strengths and weakness of market-based EG&Ss are presented on the examples below.

2.7.1.1.Wetland mitigation banking

Wetland mitigation banking is a market mechanism that reveals values of wetlands through market exchanges. The creation of compensatory mitigation banking was established in United States in 1990, when the Department of the Army Corps of Engineers (Corps) and the Environmental Protection Agency (EPA) entered into a Memorandum of Agreement (MOA) which recommended that U.S. policy strive for no net loss of the nation's wetlands. The MOA states that "*mitigation banking may be an acceptable form of compensatory mitigation*", in which

a wetland or stream restoration, creation, enhancement, or preservation project is undertaken expressly to provide compensatory mitigation in advance of authorized impacts (Wilkinson & Thompson, 2006). The institutional structure established to enable this market exchange specifies that when an individual (the permittee) applies for a permit for a project that will impact wetlands or waters of the United States, a Corps regulatory official assesses the wetland functions that will be lost and determines what mitigation is required: normally the permittee is required to do the mitigation themselves, but under some circumstances, the Corps allow them to purchase mitigation banking credits, or make a payment in-lieu of mitigation. These are often attractive substitutes to permittees since it relieves them of the time, risk, and financial liability of undertaking the mitigation themselves. However, even when given this choice, some permittees may choose to do the mitigation themselves if they have an ideal site for mitigation (Kubert, 2007).

In US, the average amount of compensatory mitigation required by the Corps averaged about 19,020 hectares (47,000 acres) per year between 1999 and 2003 (Kubert, 2007). However, during this time the number of mitigation banks has almost doubled, suggesting that Corps regulators are increasingly shifting away from requiring permittee-responsible mitigation and instead allowing mitigation banking to fulfill compensatory mitigation requirements for permittees (Martin, Brumbaugh, & Scodari, 2006). When a permittee is authorized to provide compensatory mitigation through use of a commercial mitigation bank or in-lieu fee program, the cost to the permittee is the credit price (fee rate) charged for the amount of credits deemed necessary by the District Engineer (Martin, Brumbaugh, & Scodari, 2006). There is a considerable variation in wetland credit prices within and across the United States. The table below presents some of the wetland credit prices charged by commercial mitigation bank and In-Lieu fee program.

Table 2.1. Wetland credit prices charged by commercial mitigation bank and In-Lieu fee program

Corps Division	Wetland Credit Prices Charged by Commercial Mitigation Banks	Wetland Credit Prices Charged by In-Lieu Fee Programs
Lakes and Rivers	$7,000- $145,000	$12,000
Mississippi Valley	$1,500- $100,000	$18,000
North Atlantic	$16,000- $350,000	$16,000- $350,000
Northwestern	$40,000- $120,000	$30,000
Pacific Ocean		$500-$30,000
South Atlantic	$4,000- $65,000	$12,000- $122,000
South Pacific	$400,000	$125,000
Southwestern	$2,200- $25,000	$3,000- $30,000

Source: Martin, Brumbaugh, & Scodari, (2006)

Notwithstanding, the US wetland mitigation banking experience proved to produce heterogeneous results. According to BenDor *et al.* (2009), this program provides mitigation in different ways for different types of permittees and at great distances from the original impacts. Such issues may be among causes for wetland mitigation banking not being commonly practiced by any jurisdiction in Canada (Rubec & Hanson, 2009).

2.7.1.2.Fee hunting

Another example of a market mechanism for ecological goods and services, fee hunting is the monetary amount landowners charge for hunting access to their property as enabled by the appropriate property rights (Jordan & Workman, 1989). For example, if hunters want to enter in a farm for hunting purposes, a licence should (at least verbally) receive permission from the landowner, who has the right to deny, accept with no charge, or accept under payment condition the access to the land they own. According to the United Sates government, while wildlife residing on the land is a public good, the right to hunt on private lands is a private good controlled by landowners, one that can be sold to hunters willing to pay a fee (Ribaudo *et al.*, 2008). Fee hunting has been viewed as one means of resolving conflicts over hunter access to private land and wildlife requirements for private land habitat. It is also argued that fee hunting

gives the landowner an incentive to use agricultural practices that maintain or enhance wildlife habitat, to actively coordinate with state wildlife management agencies to manage wildlife to their mutual benefit, and to keep their land open to hunters and provide a variety of hunting opportunities (Jordan & Workman, 1989).

Hunting is a popular recreation activity in the United States. Private lands are an important source of hunting opportunities. The U.S. Fish and Wildlife Services' 2001 Fishing, Hunting, and Wildlife Associated Recreation survey (FHWAR2001) found that almost 75 percent of hunting days occurred on private land, 57 percent of all hunters hunted only on private lands, and nearly two-thirds hunted at least part of the time on private land. However, while 77 percent of farmers allowed hunting, only 5 percent charged a fee according to a 1993 national survey (Conover, 1998). The average gross revenue from fee-based recreation activities ranged between $13,000 and $18,000 per farm offering these activities between 2000 and 2005 (Ribaudo *et al.*, 2008). These numbers may be important information to policy makers since it helps to understand the demand for wildlife as a component of the EG&S provided by agricultural land. Part of the revenues generated by fee hinting can also be reverted to habitat conservation (Ribaudo *et al.*, 2008).

2.7.2. Non-market valuation method

Although market measures can help EG&S provision many goods and services have no standard market information. In fact, many aspects of natural resources, and in particular EG&S, fit into this category (Kanninen, 2006). For example, under current institutions one may not be able to buy or sell a deer, the beauty of a wetland view or clean air. But these are "goods" that people care about and hold values for. In the absence of markets (such as real estate or travel, for example), economists can estimate these values by two different ways: observing information about related goods (indirect use values) or asking people about them (non-use values - direct methods) (Kanninen, 2006). These are the principles of two different approaches: the revealed preference and the stated preference, respectively. The indirect use values of wetlands are associated with EG&S that contribute to consumer utility and producer profits by supporting and preventing damage to a wide variety of economic activities (Scodari, 1997). These outputs

include pollution assimilation and detoxification; protection of property from damaging effects of floodwaters, storm, winds, and waves; and protection of navigable waterways from sedimentation. Generally, these benefits do not depend on active or intentional use. Because of this, some argue that the linkages between ecological services and economic activity are too indirect and nonspecific to assess wetland benefits using revealed-preference approaches (Scodari, 1997). The revealed-preference valuation techniques include travel cost and hedonic price methods (the hedonic price method is detailed in the following section).

However, for some goods indirect use values techniques may not be appropriate for not all goods have observed information. Because these values are not systematically revealed in market choices, the valuation techniques require methods that directly ask people about their preferences (Scodari, 1997). The most commonly applied methods of eliciting values to those goods are the Contingent Valuation (CVM) and Choice Method (CM) (Train, 2002).

2.7.3. Hedonic pricing

Hedonic models identify price factors according to the premise that price is determined both by internal characteristics of the good being sold and external factors affecting it. This method has been applied to a wide range of goods and services in recent years. For example, Mahan *et al.* (2000) estimate the value of urban wetland amenities in the Portland Oregon metropolitan area using sales prices of residential housing. Housing prices have also been used in a range of studies to estimate values for urban green space (Kong *et al.*, 2007), airport noise (Cohen & Coughlin, 2008; Dekkersa & van der Straaten, 2009), beetle infestation damage (Pricea *et al.*, 2010) and air quality (Anselin & Lozano-Gracia, 2009). Hedonic pricing has also been applied to eliciting values of attributes of goods such as mobile phone (Dewenter *et al.*, 2007), personal digital assistants (Chwelosa *et al.*, 2008), fresh tomatoes (Huang & Lin, 2007), water bottle size (Hea *et al.*, 2008), French Canadian paintings (Hodgson, 2009), costal features attractiveness (Hamilton, 2007) and ski resort characteristics (Falk, 2008). Hedonic pricing also has come to play a growing role as a non-market valuation method applied in measuring ecosystem services. Consider a (marketed) good/service as a bundle of characteristics (example proposed by Mishra, 1998). A buyer has a demand for a number of these characteristics (maybe,

not all characteristics that the said bundle possesses) and pays for them. A decrease in the quantity or quality of the desired characteristics will lower the demand for the bundle (good/service) and thus will affect its price adversely and vice versa. In this vein, marketed products may be tied with some environmental goods/services. When a person buys those goods/services, he also buys the environmental goods/services tied with them. The buyer pays not only for the marketed goods/services, but also for the package that includes the linked environmental goods/services. A diminution of environmental goods/services, therefore, degrades the package and lowers its price. This fact is used by the hedonic pricing method for valuation of environmental goods and services. Therefore, this method is most suitable to assess the value of local environmental attributes (Mishra, 1998). It is used to estimate economic benefits or costs associated with environmental quality.

While hedonic pricing has been used to estimate value for a range of goods and services, it is limited in that it is applicable only to valuation of those goods/services that are tied to a marketed goods/services and the prices of the latter respond to changes in the quality/quantity and attributes of the former. It is also assumed that nothing else modifies the relationship between them (Mishra, 1998). Further, this method demands a rich data base and reliable estimation methods. It is also susceptible to the choice of model specification used to estimation at hand. A wrong specification of the model or the method of estimation may easily underestimate or overestimate valuation of environmental goods/services (Mishra, 1998). This would raise a special concern for wetland valuation in Saskatchewan prairies, since there is very little information about marketed goods/services tied related with wetland attributes in privately owned land.

2.7.4. Contingent Valuation Method (CVM)

Contingent Valuation is an economic valuation technique, which directly elicit consumers' preferences for some proposed market conditions. It can be grouped under the family of non-market environmental valuation stated preference technique, which aims to quantify the EG&Ss of non-market attributes into monetary or market values (Pek, Tee, & Ng, 2010). CVM is survey-based and widely used. CVM was first proposed in theory by Ciriacy-Wantrup (1947)

and first applied by Davis (1963) to estimate the value hunters and tourists placed on a particular wilderness area. Since then, CVM has become more established and is currently a widely accepted technique (McLean & Mundy, 1998). Pattison (2009) for example, have used CVM to estimate values for wetland restoration and retention in the prairie pothole region of Manitoba, which estimated values between $290 (retention) and $360 (full restoration) per household per year. Roberts and Leitch (1997) determined the value of wetland services in Mud Lake, South Dakota to be $926 per hectare ($375 per acre) per year. Leitch and Hovde (1996) analyzed five prairie pothole wetlands in North Dakota, and found that WTP estimates varied from $10 to $921 per hectare per year, depending upon the stakeholder perspectives and the wetland being considered

Although contingent valuation methods are commonly used, it is also the most controversial of the non-market valuation methods. CVM requires people to respond to a specific hypothetical scenario; therefore, there is an assumption that respondents understood the good in question and answers the survey truthfully. Recently, many techniques have been created to minimize hypothetical bias caused by the assumptions above. The most popular possible solutions to this problem are *cheap talk* (proposed by Cummings & Taylor, 1999); *statistical calibration functions* (demonstrated by Fox *et al.*, 1998) and *follow up certainty questions* (see Champ *et al.*, 1997). First, cheap talk explicitly states to participants the importance of truthful behaviour during the survey. Many authors found this technique efficient to reduce hypothetical bias (Lusk, 2003; Aadland & Caplan, 2003), while other found it efficient only for respondents facing relatively high payments (Murphy, Stevens, & Weatherhead, 2005), or only for inexperienced participants (List, 2001). Second, statistical calibration functions use laboratory experiments involving real payments to calibrate the survey data (Fox *et al.*, 1998). However, List and Shogren (2002) argue that these functions are often thought to be commodity, context, and/or individual specific. Finally, Champ and Bishop (2001), Ethier *et al.* (2000) and Poe *et al.* (2002) have all used an uncertainty scale whereby uncertain WTP ‘yes‘ responses are recoded as ‘no‘. Although this technique has proved to be effective in many situations, the cut-off point at which this practice works is arbitrary and varies among studies. Moreover, Wang (1997) found that treating uncertain responses as ‘no’ can underestimate mean WTP. Therefore, despite the existence of tools to minimize hypothetical bias in CVM studies, the literature is inconclusive about its efficiency (Aadland & Caplan, 2006).

2.7.5. Choice method (CM)

Similarly to CVM, CM uses surveys in hypothetical scenarios to estimate economic values. However, CM studies describe goods or services as a collection of attributes. By varying the attribute levels, the researcher creates different "goods." In other words, CM studies resemble experiments in which the researcher can manipulate attributes and levels to see how people react (Bateman, et al., 2005). CM studies represent an important form of experimentation that lies somewhere along the spectrum between laboratory experiments and observational studies (Harrison & List, 2004). Comparing the presented stated models, Boxall *et al.* (1996) found significant difference between CVM and CM used to value environmental quality changes arising from forest management practices on recreational moose hunting values, and suggested that CM may be more appropriate than CVM. The method is particularly suitable for estimating marginal rates of substitution between different attributes of for example a wetland. For example, Morrison et al. (1999) applied a choice experiment to estimate non-use environmental values of a wetland area in Australia. In particular they investigate the trade-off between non-use values in job losses and environmental quality. In their study they created 4 different management scenarios with different levels of the attributes they were considering. The range of prices households were willing to pay for the hypothetical management scenarios was $22.36 – $102.62. In addition, their results indicated that while the existence values for improved environmental quality outweighed the existence values for rural employment (including employment effects has reduced WTP by 20-30% in the scenarios they considered). Other example of CM use for wetland valuation with the general objective of estimating WTP for wetland area itself, in particular the use and non-use values of improved environmental quality are Adamowicz *et al.* (1994). For instance, Carlsson *et al.* (2003) were more interested in valuing different wetland attributes, such as surrounding vegetation, biodiversity, fish, fenced waterline, crayfish and walking facilities in Staffanstorp, southern Sweden. These authors found heterogeneous preferences for several attributes, negative mean WTP for "meadow land", "fenced waterlines" and "crayfish" and the highest WTP for "Biodiversity" and "walking facilities".

The use of CM for wetland valuation has been commonly applied in recent studies and with wide range of attributes and values. The results of these studies depend largely on the CM design. There are numerous different design options, and different actors may promote different alternatives. Whether researchers' objectives are to design a wetland for nutrient retention alone, or provide policy makers information about the value of different options, by conducting a choice experiment, one is able to identify attributes that increase and decrease citizens perceived value of wetlands (Carlsson *et al.*, 2003). The next chapter presents the analytical framework which provides the foundation for some of the research design options presented later in Chapter 4 (which explore the Choice Method in detail).

2.8. Summary of the policy measurements for wetland conservation

Wetlands provide an important range of EG&S to Saskatchewanians. However, many of these EG&S are being undersupplied, or lost due to the inability of markets to efficiently provide the necessary incentives from a social welfare perspective. Thus, policy measures are established to help fill these gaps by balancing the perceived responsibilities and interests held by society and landowners for providing EG&S. Many policy mechanisms can be used for different purposes, with different features and implications, and in many situations a combination of them is desired for efficient outcomes. Economic incentives, for example, provide a wide variety of flexible cost efficient mechanisms for environmental improvement. Similarly, many valuation technics can be used to help in the development of economic incentive policies. For example, the choice model can provide important valuation information for wetlands located on privately owned agricultural land. This information is important for designing an effective economic incentive policy. Chapter 3 provides details of how the choice model can provide values for wetland conservation by presenting an analytical framework.

3. CHAPTER - ANALYTICAL FRAMEWORK

3.1.Introduction

The demand for EG&S valuation to help inform development and policy decisions has experienced a significant increase in the past 10 to 15 years. One of the primary economic issues is the fact that by leaving resource management decisions to be determined by the market, EG&Ss will tend to be undersupplied (from a social welfare perspective) resulting in inefficient resource allocation. The under-supply of EG&S on the agricultural landscapes is often explained in economic terms as a market failure. For example, the under-provision of wetland EG&S in agricultural Saskatchewan (Johnson, *et al.*, 2005). This chapter presents an analytical framework to help evaluate the costs and benefits associated with wetlands located on privately owned agricultural land. The framework will be applied to analyze the specific problem in the following chapter. The chapter will begin by discussing factors causing the market failure and the influence of market failure in allocating agriculture land. Then a graphical model will be developed to further illustrate the problem in wetland demand and supply and show how policy could be used to address the inefficiency. Finally, the framework is detailed in order to provide guidance on how policy makers can measure social wetland demand.

3.1.1. Wetland demand

The literature indicates that market failures are the major reason wetland resources are undersupplied from a social welfare perspective. Within North American agricultural landscapes "the vast majority of the land and therefore the wetlands within these land holdings are usually privately owned" (Farnese and Belcher, 2006). In most cases, the potential loss of EG&S from

wetlands is not factored into the decisions of those whose behaviour affects the wetland. That is, they are not reflected in prices paid for the right of access to wetland resources, or received for the output of wetland-based activities. These losses of EG&S are external to the market. A consequence of this incomplete information is the extensive conversion of wetlands that has occurred over the last 50 plus years. Butler and Macey explain, "Since individuals in a market system respond only to the benefits and costs that they actually receive and pay for, the market system may be inadequate to deal with externalities" (Lee, 2006, citing Butler and Macey). Baliga and Maskin (2003) argue that an allocation that maximizes the benefits to all of society will not be the outcome without government intervention when the externality is non-excludable (a pure public EG&S for example). Specifically, the major objective of government intervention in the context of these types of market failures is to encourage the increased supply of environmental goods and services through changing the land allocation to benefit society. The following section introduces a graphical model to further explain why wetland conversion actions happen and the role of public policies to address the problem.

3.2. A Graphical Model of Land Allocation

This section presents a stylized framework that explains the factors determining the allocation of wetlands on Agricultural land. Described by Heimlich *et al.* (1998), the following diagrams (figures 3.1 which presents the wetland allocation form landowners' perspective only, and figure 3.2 which presents the wetland allocation after introducing social values) demonstrates how improve protection and converting wetlands translate into observed and optimal levels of wetland preservation and conversion by differing private and public incentives. The function (MB) describes the marginal benefit individual landowners realize with different allocations of land to wetland conservation or agricultural production. The vertical axis represents an index of value, such as dollars per hectare. The horizontal axis represents the total initial stock of wetland. This initial stock has subsequently been allocated to one of two categories: protected wetland area P (measured from the left-hand side) and area of land

converted from wetland to some other use C (measured from the right-hand side). Thus, the landowners MB decrease or increase according to whether wetlands are protected (P) or converted (C).

Consider the net marginal benefit individual landowners realize by protecting an incremental hectare of wetland (MB_p^i)[6]. Examples include private scenic, recreational use values such as fishing or hunting, or economic returns from grazing or timber harvesting. Thus, as more wetland hectares are protected (moving from left to right), landowners' marginal benefits for protecting an additional hectare of wetland decrease (figure 3.1a). Note that this curve is downward sloping because it assumes diminishing marginal utility for *preservation*. For example, imagine a landowner producing crops and having all his wetland drained. For this landowner, this model assumes that benefit for the first hectare protected is very high, but as more wetland are protected (and therefore the crop area is reduced) the marginal benefit for an extra unit of wetland protected decreases. Likewise, MB_c^i would be expected to increase as the remaining area of protected wetlands decreases (moving from right to left). Therefore, the model also assumes increasing marginal utility for *converting* wetland into agriculture (MB_c). For example, if a landowner has all his land protected (therefore not producing any agricultural commodity), the benefit for converting the first hectare of wetland into agriculture is assumed to be very high. However, as more wetland is drained (moving from right to left), the benefit of additional conversion diminishes.

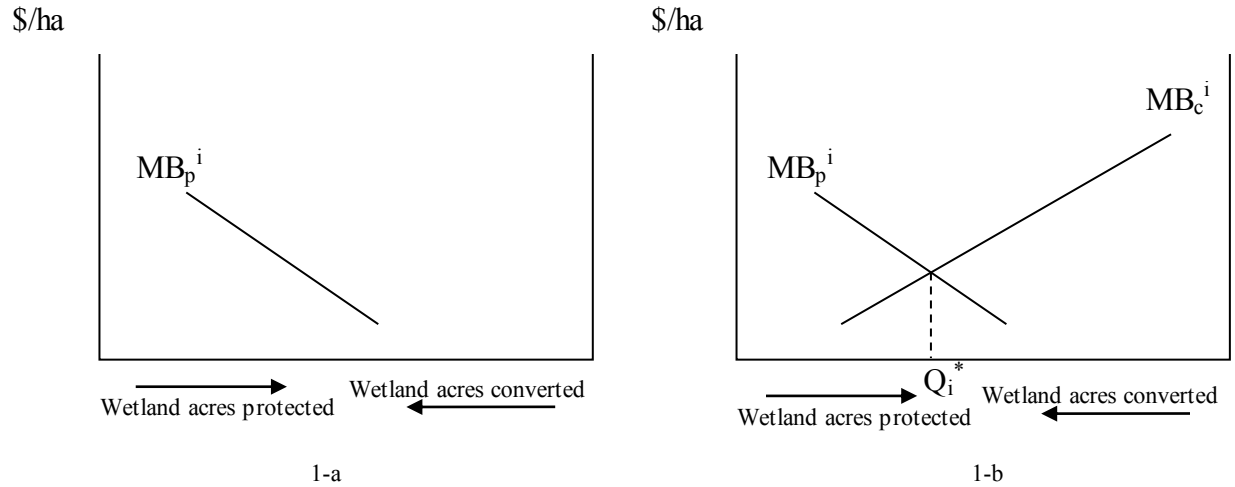


Figure 3.1. Wetland allocation from the **landowners'** perspective.
Source: adapted from Heimlich *et al.*, (1998).

[6] Due to conceptual and measurement difficulties, the true level and shape of this curve is not known with precision. The same is true for the other curves introduced below (Heimlich *et al.*, 1998).

Now, Figure 3.1-b represents the net marginal benefit individual landowners realize by protecting wetlands, as presented in Figure 3.1a, and the marginal benefit realized by the landowner by converting an incremental hectare of wetlands to the production of agricultural commodities (MB_c^i). In contrast to individual benefits from wetland protection, MB_c may be relatively high, since conversion makes possible more intensive agricultural or developed uses that provide economic returns directly to the individual landowner through the sale of commodities. MB_c^i would be expected to decline as the area of converted wetland increases (moving from right to left). The privately optimal allocation of the stock of wetlands is represented by the point (Q_i^*) where the two marginal benefit curves cross. At this point, protecting an additional hectare would cost more in terms of foregone benefits from conversion than would be gained in benefits from protection. Likewise, converting an additional hectare would cost more in terms of foregone benefits from protection than would be gained in benefits from conversion. This simple framework can be extended to illustrate the differences between the public and private incentives to protect and convert wetlands.

Both conversion and protection generate public benefits as well as private benefits. In the case of wetland conversion to agricultural production, for example, these benefits may include increased agricultural output, lower consumer prices for food commodities and, in the 19th century, westward expansion and settlement (Heimlich *et al.*, 1998). However, it is expected that public benefits to conversion are now small relative to private benefits since settlement has been accomplished and remaining wetlands are small relative to the cropland base. Adding these incremental public benefits, in the form of externalities (or external benefits) to the landowner, to the individual benefits curve MB_c^i results in a social marginal benefit curve for conversion of MB_c^s (figure 3.2- a).

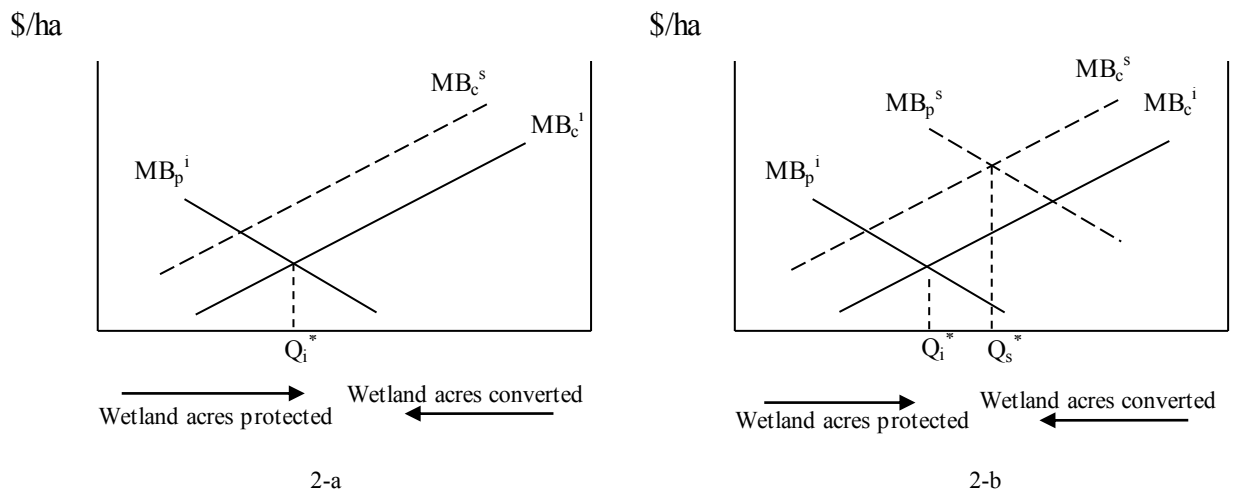


Figure 3.2. Wetland allocation from the private decision maker perspective after introducing social values.
Source: adapted from Heimlich *et al.*, (1998).

In the case of wetland protection, on the other hand, there are significant externalities, or social benefits provided. Examples of these benefits that tend not to be realized by the private landowner include flood control, water quality improvement, fish and wildlife habitat, and recreational opportunities. Adding these externalities to the individual marginal benefits curve MB_p^i results in the significantly higher social marginal benefit curve for protection of MB_p^s, as depicted in figure 3.2-b. Thus, external benefits are represented by the shift from MB_p^i to MB_p^s. Denoted in equation, $MB_p^s = MB_p^i$ + externalities. The socially optimal allocation of the initial stock of wetlands (Q_s^*) thus occurs to the right of the privately optimal allocation (Q_i^*), representing relatively more wetlands protected and less converted than under the privately optimal allocation. According to this model to increase social welfare, more wetland and riparian areas must be conserved with less land allocated to agricultural production. Since external social benefits are not reflected in the market, and as such landowners fail to receive adequate incentives to increase wetland conservation to socially optimal levels, government policies may be required to enable the market to provide the maximum social welfare.

The model discussed above provides a general conceptual picture for understanding the allocation of land within an agricultural landscape. For individual landowners, they will stop converting wetlands when the marginal benefits of converting are equivalent to the marginal benefits of protecting. Due to the market inefficiency problem of wetlands, there exists a gap between the actual and the socially optimal allocation of land between protected and converted

wetland. To minimize the divergence, policy measures can be implemented. However, the framework provides little guidance on how policy makers can measure society wetland demand. Therefore, the development of appropriate policy requires information on the values that society holds for the EG&S provided by wetlands which are considered below.

3.3. Theoretical Support of Behavioral Model

The principle that in the presence of externalities goods are not efficiently allocated by market suggests the possibility of improvement by public action. The graphical model, presented earlier, provided the framework for the possibility of improvement of resource allocation. However, for a policy perspective the benefits from public action (e.g. required to shift MB up) should exceed the costs of the action in order to be worthwhile. In other words, the benefits acquired from the improvement necessary to bring the privately optimal allocation (Q_i^*) to the socially optimal allocation (Q_s^*) should exceed the costs of such change.

There are two ways to describe the monetary magnitude of a welfare measure. First, compensating variation can be defined as the amount of income paid or received that leaves the person at the initial level of well-being, or equivalent variation which is the amount of income paid or received that leaves the person at the final level of well-being. Second, willingness to pay/accept is the maximum amount of income a person will pay/accept in exchange of a good or service (including environmental improvement). As Haab and McConnell (2003) state, both mechanism measures the same phenomenon: "*the increment in income that makes a person indifferent to an exogenous change, where the change might be price change, a quality change, or a change in some public good*". Analytically, the relationship between these welfare measures can be expressed according to the equation (3.1) (described by Haab and McConnell, 2003).

$$V(p, q^*, y - WTP) = V(p, q, y) \qquad (3.1)$$

Where q is the vector of public goods and services being provided by the vector price, p, subjected to income, y; and, $V(\cdot)$ is the indirect utility function. Within the context presented in section 3.2, it's possible to consider the socially optimal allocation (Q_s^*) as q^* and the privately

optimal allocation (Q_i^*) as q at equation (3.1). Therefore, $q^* \geq q$, and holding everything else constant, an increase in q is desirable ($\partial V/\partial q > 0$). Equation (3.1) also restates the WTP[7] role in the model as the amount of income an individual would give up to make him indifferent between the original state and the socially optimal allocation (at q^*). The WTP for a price change (let the price vector decline) is defined as (Haab & McConnell, 2003):

$$WTP = m(p, q, u) - m(p^*, q, u) \text{ when } u = V(p, q, y) \quad (3.2)$$

The variables in which individual state their preference are p and q. However, the economic decision with regard to q and p choices for an individual is often complex. According to Louviere *et al.* (2000), there are several steps when individuals decide the goods and prices for their consumption. Consumers first become aware of their consumption needs which are followed by a period of information search in which they learn about products that can satisfy these needs. During this stage, beliefs about the available products to attain their objectives are formed by consumers. The product attributes contribution to a choice and the attributes values offered by products as well as any associated uncertainty become important in this stage. Eventually, consumers gather enough information to form a utility function, which involves valuing and trading off products attributes that matter in the decision. Finally, if consumers decide to purchase one or more alternatives must be chosen in certain quantities and with particular timing of the purchase.

However, economists are mainly interested in market demand. The fact that each individual makes consumption decisions based on individual needs, and that these decisions are complex, makes the relationship between market and individual demand even more complicated (Louviere, Hensher & Swait, 2000). For example, McFadden (1979) showed that the utility maximization allow the possibility that unobserved attributes of individuals can vary over population in such a way that they obscure the implications of the individual behaviour mode. To advance this discussion, a general procedure for formulating models of population choice behaviour from distributions of decision rules in the population when commodities are discrete is developed below.

[7] The present section provide general considerations of the WTP within the framework. For more detail of how the WTP is estimated in the Choice model, see section 3.4.4.

3.4.Choice Model (CM) Specification

The measurement approach adopted in this thesis can provide important information to policy makers about social preferences for EG&S. CM[8] is consistent with random utility theory (RUT), which can be derived as follows (McFadden, 1979)[9]. Consider a decision maker (e.g. a Saskatchewan resident), n, faces a choice among J alternatives (e.g. conservation programs, or wetland EG&S). The decision maker would obtain a certain level of utility from each alternative. The utility that decision maker n obtains from alternative j is U_{nj}[10], $j = 1, \ldots, J$. The decision maker chooses the alternative that provides the greatest utility. Within the behavioural model alternative i is chosen if and only if $U_{ni} > U_{nj}$, for all $j \neq i$ (Train, 2002). Note that the individual utility is known by the decision maker but not by the researcher.

The researcher observes some attributes of the alternatives faced by the decision maker, x_{nj}, and some attributes of the decision maker, s_n, and can specify a function that relates these observed factors to the decision maker's utility. This function follows a strictly additive form denoted $V_{nj} = V(x_{nj}, s_n)$, and is often called *representative utility* (Train, 2002). Note that, V depends on parameters that are unknown to the researcher and therefore estimated statistically. Since, by using CM some of this unobservable consumer utility can be explained and some proportion remains unexplained, $V_{nj} \neq U_{nj}$. In fact,

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{3.3}$$

Where U_{nj} is the latent, unobserved utility for choice alternative, V_{nj} is the systematic, observable component of the latent utility and ε_{nj} is the random component of the latent utility associated with option j and consumer n (Train, 2002). The term ε_{nj} is unknown, and therefore it is treated as random. The joint density of the random vector, ε_n, leads to the expression of the probability of choice (Train, 2002):

---

[8] See section 2.7.5 for a brief comparison between two of the most common stated preference methods (CVM and CM).

[9] McFadden (1979) is seminal to the development of discrete choice models, His work on CM was awarded with the Nobel Memorial Prize in Economic Sciences in 2000. Later, Train (2002) didactically describe CM in a text book.

[10] *U_{nj} can be formally defined as the utility individual n obtain when choosing alternative j.*

$$P_{ni} = \text{Prob}[(V_{ni} + \varepsilon_{ni}) > (V_{nj} + \varepsilon_{nj})] \quad (3.4)$$

$$= \text{Prob}(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj})$$

$$= \int_{\varepsilon} I(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj})\, f(\varepsilon_n)\, d\varepsilon_n \quad (3.5)$$

for all $j \neq i$,

P_{ni} is the probability individual n chooses the alternative i. $I(\cdot)$ is the indicator function, equalling 1 when the expression in parentheses is true and 0 otherwise. This is a multidimensional integral over the density of the unobserved portion of utility, $f(\varepsilon_n)$. But, what is meant by the distribution of ε_n?

The interpretation that the researcher places on this density affects the interpretation of the choice probabilities. The most transparent way to think about this distribution is described by Train (2002), as follows. Consider a population of people who face the same observed utility V_{nj} $\forall j$ as person n. Among these people, the values of the unobserved factors differ. The density $f(\varepsilon_n)$ is the distribution of the unobserved portion of utility within the population of people who face the same observed portion of utility. Under this interpretation, the probability P_{ni} is the share of people who choose alternative i within the population of people who face the same observed utility for each alternative as person n. The distribution can also be considered in subjective terms, as representing the researcher's subjective probability that the person's unobserved utility will take given values. In this case, P_{ni} is the probability that the researcher ascribes to the person's choosing alternative i given the researcher's ideas about the unobserved portions of the person's utility. As a third possibility, the distribution can represent the effect of factors that are quixotic to the decision maker himself (representing, e.g., aspects of bounded rationality), so that P_{ni} is the probability that these quixotic factors induce the person to choose alternative i given the observed, non-quixotic factors.

Different discrete choice models are obtained from different specifications of this density, that is, from different assumptions about the distribution of the unobserved portion of utility. Examples of models derived from the specifications of the density function include Logit, Nested Logit, Mixed Logit, and Probit. Logit and nested logit have close-form expressions for the intergral, $f(\cdot)$. These models are under the assumption that the unobserved portion of utility is distributed iid extreme value (logit) and a type of generalized extreme value (nested logit). On

the other hand, Mixed logit and Probit are more flexible due to their open-from expression for the integral, $f(\cdot)$. Mixed logit models are derived under the assumption that the unobserved portion of utility consists of a part that follows any distribution specified by the researches plus a part that is iid extreme value. Probit models are based on the assumption that the unobserved factors are distributed jointly normal. Despite less flexible, logit models are relatively easy to apply and very popular. This study opted for two models, a close-form easier to use and popular logit, more especially the *conditional logit model* and a more flexible mixed logit, the *random parameter logit.* The assumptions made for the *conditional logit model* and *random parameter logit*, as well as its strength and weakness are considered in more detail at the sections below.

3.4.1. Conditional logit derivation

According to Train (2002), logit models are by far the most widely used discrete choice models. Among the reasons for this popularity is that logit is relatively easy to apply, the formula for the choice probability takes a convenient closed form and it's readily interpretable. For example, the representative utility for the logit is specified to be linear in parameters: $V_{nj} = \beta' x_{nj}$, where x_{nj} is a vector of observed variables (all attributes) relating to alternative j. Therefore, the probability that respondent n picks alternative i out of all alternatives under the logit model is:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{{}_j e^{\beta' x_{nj}}} \qquad (3.6)$$

However, the most important assumption of the logit is that the error term for individual n choosing alternative i (ε_{ni}) is independently, identically distributed (iid) extreme value for all i. In fact, the logit model is derived from this assumption[11] (Train, 2002). Note that according to equation (3.5), the model is interested in the differences between error terms, and the difference between two extreme value variables (e.g. . $\varepsilon_{nj} - \varepsilon_{ni}$) is distributed logistic. In other words, "*if* ε_{nj}

[11] The logistic function was invented in 19th century for the description of the growth of populations and the course of autocatalytic chemical reactions. Despite, only in 1973 the multinomial logit is linked to the theory of discrete choice from mathematical phycology, which is credited to McFadden (1974). For a detailed history of the logit model see Cramer (2003).

and ε_{ni} *are iid extreme value, then* $\varepsilon^*_{nji} = \varepsilon_{nj} - \varepsilon_{ni}$ *follows the logistic distribution*" (Train, 2002 p.39).

There are many desirable properties that the logit model exhibits. First, P_{ni} (equation 3.4) is necessarily between zero and one, as required for a probability. However, the logit probability for an alternative is never exactly zero, since if the alternative has actually no chance of being chosen by a decision maker, the researcher can exclude that alternative from the choice set (Train, 2002). Second, the choice probabilities for all alternatives sum to one ($_{i=1}^{J} P_{ni} = 1$). In other words, the decision maker necessarily chooses one of the alternatives. Finally, the relation of the logit probability to representative utility is sigmoid, or S-shaped, as shown in Figure 3. This shape has implications for the impact of changes in explanatory variables. Note that in a sigmoid function, changes in V_{ni} have little impact in the probability of participant n choosing alternative i when preferences are strong. In other words, if one alternative is far superior or very low compared with other alternatives in observed attributes, a further increase in its representative utility has little effect on the choice probability. However, if probability, P_{ni}, is close to 0.5 (50–50 chance of the alternative being chosen), small changes in V_{ni} have large impact in the probability of the alternative being chosen (Train, 2002). These impacts of changes in explanatory variables due to the sigmoid shape of logit probabilities is shared by most discrete choice models and also has important implications for policy makers. For example, improving wetland services in areas where the services are so limited that few people have access to the benefits would be less effective, than making the same improvement in areas where wetland services are already sufficiently good to induce a moderate share of people to choose it (but not so good that nearly everyone does). The policy insights from the models used in this study is presented on chapter 5.

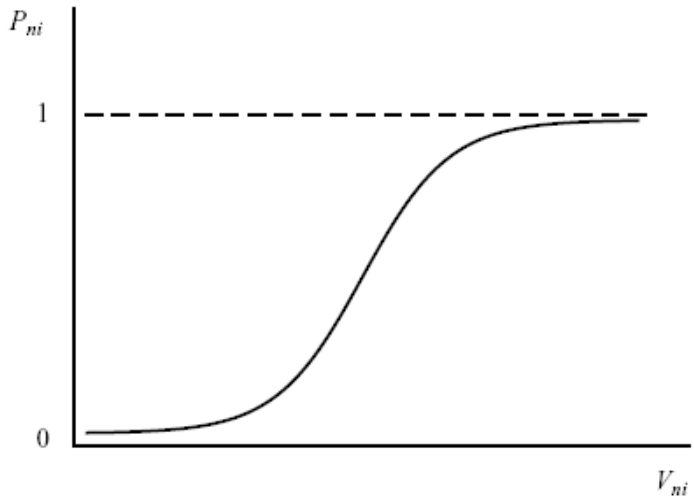


Figure 3.3. Graph of logit curve.

Source: Train (2002).

However, the key restrictive assumption responsible for the development of other models it's not the shape of the distribution, but that errors are independent from each other. In other words, the unobserved portion of utility for one alternative is unrelated to the unobserved portion of utility for any other alternative. For example, in a wetland experiment, the unobserved factors that makes participant choose to conserve wildlife population must not be correlated to the unobserved factor for water quality. A situation where wildlife habitat and water quality errors may actually be correlated is when participants believe that improving water quality can lead to an increase in wildlife population and this is not captured in the specified model (for example V, equation 3.4). The next section discusses this assumption in more detail.

3.4.2. Independence from Irrelevant Alternatives (IIA)

Independence from irrelevant alternatives is a property of the conditional logit model, and it's often the reason for researchers to choose other models. The popularity of the logit model is due to the convenient closed form, which assumes independence from irrelevant alternatives. However, this assumption can be inappropriate in some situations. Consider the ratio of the logit probabilities (P_{ni}/P_{nk}) for any two alternatives (i and k). According to the definition of IIA, this ratio does not depend on any alternatives other than i and k. Whether IIA holds in a particular

setting is an empirical question, amenable to statistical investigation (the test for IIA as applied in the present study is detailed in Appendix C).

For instance, consider the following situation. Consumers of a resort initially face a decision between two recreational activities: ride a horse or a quad bike. Suppose that a consumer chooses between these two options with equal probability, 0.5, so that the odds ratio equals 1. Now suppose a third option, a mare with the same physical and riding characteristics of the horse, is added. Assuming rider consumers do not care about the horses' gender, consumers are expected to choose between horse and quad still with equal probability, so the probability of quad is still 0.5, while the probabilities of each of the two animals is 0.25. But IIA implies that this is not the case: for the odds ratio between quad and male horse to be preserved, the new probabilities must be: quad 0.33; horse 0.33; mare 0.33. In intuitive terms, the problem with the IIA axiom is that it leads to a failure to take account of the fact that riding horse or mare are very similar, and are "perfect substitutes".

3.4.3. Random Parameter Logit (RPL) Model

Differently from the conditional logit model, that considered parameters (βs) fixed (see equation 3.6), the RPL model considers β_n to be random. Therefore, the utility of person n from alternative j is specified as

$$U_{nj} = \beta_n' x_{nj} + \varepsilon_{nj}, \tag{3.7}$$

where x_{nj} are observed variables that relate to the alternative and decision maker, β_n is a vector of coefficients of these variables for person n representing that person's tastes, and ε_{nj} is a random term that is iid extreme value (Train, 2002). This specification is the same as for standard logit except that β varies over decision makers rather than being fixed (Train, 2002).

Note that β_n cannot condition on β, since β_n is unknown. The unconditional choice probability is therefore the integral of equation (3.7) over all possible variables of β_n:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{{}_j e^{\beta' x_{nj}}} \; f \; \beta \; d\beta, \tag{3.8}$$

For the purpose of this study, $f(\beta)$ is assumed to be normal. According to Train (2002) most applications, such as Revelt and Train (1998), Mehndiratta (1996), and Ben-Akiva and

Bolduc (1996), $f(\beta)$ has been specified to be normal (more recent examples include: Train, 1998; Morey & Rossmann, 2003; Carlsson, Frykblom, & Liljenstolpe, 2003).

Comparing the RPL with the conditional logit model, it's important to notice that by allowing coefficients to be random, the RPL accounts for correlation of error terms. In other words, RPL is more flexible and appropriate when the logit model is not adequate due to independence of irrelevant alternative (IIA) problem. For example, if researchers suspect that there are unobserved factors (e.g. increasing water quality) that affect the choice of other attributes (also increases wildlife population) that is not accounted in the model, the logit will be biased, but the RPL won't (Louviere *et al.,* 2000).

3.4.4. Estimation of Willingness to Pay

The estimation of willingness to pay in choice models often considered the calculus of the implicit price and compensating surplus. The implicit price for EG&S provided by wetlands describes the choice alternatives on a ceteris paribus basis. That is, they are estimations of the WTP of respondents for an increase in the attribute of concern, given that everything else is held constant (Do and Bennett, 2007). In other words, implicit prices are the marginal rates of substitution between the attribute of interest and the monetary attribute. This is equal to the ratio of the coefficient of one of the non-monetary attributes and the monetary attributes, as follows (Train, 2002):

$$\text{Implicit price} = -(\beta_{\text{non-market attribute}}/\beta_{\text{monetary attribute}}), \qquad (3.9)$$

where β are the coefficients estimated in the model.

However, the implicit prices do not provide estimates of compensating surplus (CS) for the alternative management scenarios. For policy analysis, the researcher is often interested in measuring the change in compensanting surplus that is associated with a particular policy. Compensating surplus, in choice modeling, is used to quantify the changes to individual welfare that result from different management scenarios. For example, if a new alternative is being considered, such as wetland improvement in a municipality, then it is important to measure the benefits of the project to see if these social benefits warrant the costs (Do & Bennett, 2007), in other words, has net social welfare increased with the wetland improvement project. Similarly, a

change in the attributes of an alternative can have an impact on compensating surplus that is important to assess. Degradation of the water quality of rivers harms the anglers who can no longer fish as effectively at the damaged sites. Measuring this harm in monetary terms is a central element of legal action against the polluter (Train, 2002). Whitten (2003, p.275) further states "*compensating surplus is the appropriate estimate of the willingness to pay for a change from the current situation*".

Under the logit assumptions, the compensating surplus associated with a set of alternatives takes a closed form that is easy to calculate. By definition, a person's compensating surplus is the utility, in dollar terms, that the person receives in the choice situation. The decision maker chooses the alternative that provides the greatest utility. In simple terms, Do and Bennett (2007) presented the following:

$$CS = -(1/\beta_{monetary})(V_1 - V_2) \quad (3.10)$$

where V_1 is the value of the indirect utility[12] associated with the status quo; V_2 is the indirect utility associated with the specific levels of the attributes describing the changed resource allocation, and; β is the coefficients estimated in the model.

CS from logit estimates allows policy makers to measure society wetland demand for different management scenarios. This information can be used to address issues related to wetland market failure. Chapter 4 describes the materials and method used in this study in order to apply the presented framework.

3.5. Analytical framework Summary

The under-supply of EG&S on the agricultural landscapes is often explained in economic terms as a market failure. This failure may occur due to external factors (also known as externalities) that shift the environmental supply and/or demand curve away from the optimal equilibrium. Therefore, the inefficiency of the markets creates a gap between the actual and the

[12] As explained earlier, $V_{nj} = \beta' x_{nj}$ for the Conditional Logit Model and $V_{nj} = \beta_n' x_{nj}$ for the Random Parameter Logit Model.

socially optimal land allocation for protected wetland. The development of appropriate policy can help to correct such inefficiency, however; it requires information on the values that society holds for the EG&S provided by wetlands. Consistent with Random Utility Theory, this study considers two choice models for eliciting values for wetland in Saskatchewan. First, wetland attributes are framed in an approach where features that the model cannot capture are assumed to be independent from other attributes. Despite being commonly used, this assumption is very simple, and can be a problem due to the complexity of wetlands ecosystem functions. Addressing the IIA problem, the RPL model was considered. This model allows unobserved factor of attributes to be correlated without affecting the valuation outcome. According to theory, the calculation of willingness to pay for wetland attributes is possible with the estimation of both models. Nevertheless, this theoretical approach needs to be re-assessed according to the data collected. For example, the data can indicate whether conditional or RPL is an appropriate model. Thus, chapter 4 describes the methodology used for data collection and wetland valuation.

4. CHAPTER – RESEARCH MATERIALS AND METHODS

4.1. Introduction

As described by the analytical model, the socially optimal allocation of the stock of wetlands can be achieved if landowners receive appropriate incentives. Government policies can be used to enable the market to provide the maximum social welfare. Developing such policies requires an understanding of society's perspective on wetland EG&Ss, and they can be accomplished econometrically through stated preference methods. This chapter is focused on the administration of a stated choice (SC) survey. First, a short description of the study area is presented. Second, the sample design is explained and the SC survey for this study is synthesized. The following section presents the process of selecting the individuals to receive the survey and briefly describe how that data is handled. Finally, a summary of the chapter is provided.

4.2. The study area[13]

Two major natural regions compose the province of Saskatchewan. The Laurentian Plateau (or Canadian Shield) is located in the northern area of the province, and is mostly covered by boreal forest (except for the Lake Athabasca Sand Dunes). Southern Saskatchewan, however, is where the interior plain (or Laurentian craton) is located. The southern plain is extremely important, economically, to the province, since abundant natural resources and the majority of

[13] Note that this study is limited to Saskatchewan since the primary objective is to help inform the development of effective policy to provide EG&S in the agricultural landscape of the province.

population are located here. Accounting for approximately $11 billion of value of production, Saskatchewan is one of the most important agricultural provinces in Canada (Statistics Canada, 2011). According to the 2006 census, 46% of the total land area in Saskatchewan is farm, and 58% farm land is dedicated for crops (see figure 4.1). Wheat is, perhaps, the most common crop in Saskatchewan (covering 35% of the 2006 crop area), but other grains like oats, canola, rye, peas, barley, lentils, canary seed and flax are also produced.

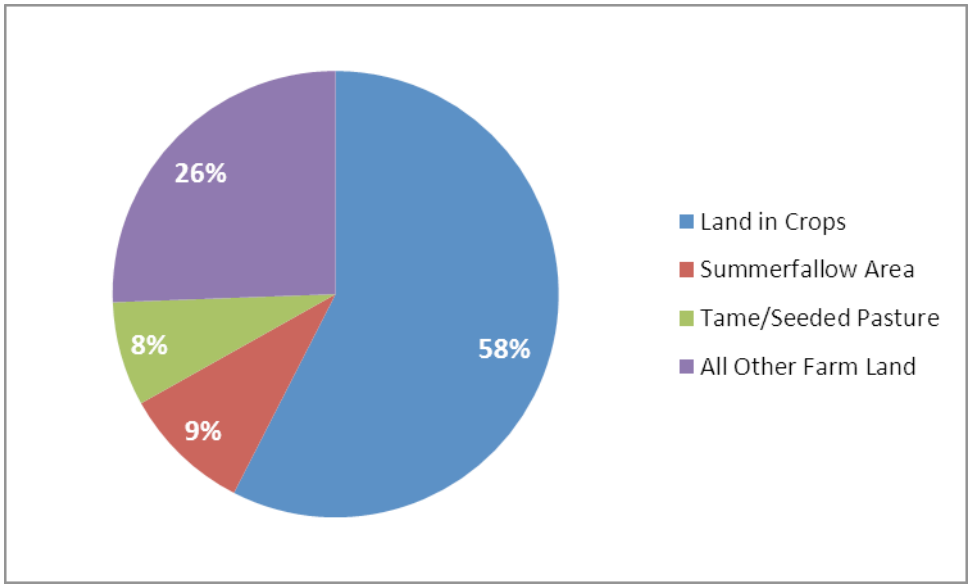


Figure 4.1. Saskatchewan land use distribution.

Source: adapted from Ministry of Saskatchewan (2006).

Agriculture, on privately owned land, is the dominant land use in southern Saskatchewan and agricultural production can provide a wide range of EG&Ss. Among the examples of EG&S that a well-managed agricultural land can provide are fish, wildlife habitat, scenic views, and purification of air and water through natural processes. Wetlands are an important source of EG&S in Saskatchewan agricultural land. However, agricultural development has imposed environmental costs for provincial society. Eleven percent of Canada's wetland are in Saskatchewan and it's estimated there are about 1.5 million wetlands covering 1.7 million hectares (4.2 million acres) in the agricultural region of the province (SWA, 2010). Wetlands historically covered up to 23% of the provincial land area, but it is estimated that 50-70% of these wetlands have been lost or altered, primarily due to agricultural drainage and cultivation.

The survey used in this study targets society's preferences towards EG&S provided by wetlands in Saskatchewan's agricultural landscape. More specifically, the survey is designed to capture society's perception of the level of responsibilities that society and landowners have in providing EG&S, and the values of these goods to inform the development of appropriate policy. The EG&Ss considered include those provided by increasing riparian areas, wildlife population and water quality (section 4.3.1 describes these EG&Ss in more detail).

4.3. The survey development

The survey instrument used in the present research was developed to elicit attitudes and values of Saskatchewan residents towards a range of EG&S provided by prairie wetlands. However, before being applied, the survey instrument was reviewed for any potential harm that the questions could cause to all the agents directly or indirectly involved in this process. After inspection, the survey was approved by the University of Saskatchewan Behavioural Research Ethics Board in May, 2010.

The structure of the survey included a *consent form*[14] to ensure that each respondent understood the nature of the survey and the implications and risks involved on completing the survey. The consent form briefly introduced the researchers responsible for the study and formally invited participants to voluntarily express their true opinions. The consent form also stated the study purpose and procedure, potential benefits and risks, how the data will be stored and the commitment from the researchers to maintain confidentiality of any particular information that is not of public interest. Participants were also given the right to withdraw from the study for any reason, at any time during the survey answering process, without penalty of any sort. Participants that decided to withdraw had all the data that they contributed destroyed.

The body of the survey was composed by four different sections. The first section provided the respondent with a brief discussion of wetland degradation in Saskatchewan. This section also provided a description of the wetland attributes that the respondent needed to respond to

[14] See the consent form in Appendix A.

within the survey. The introduction of wetland degradation is important and was meant to provide some context to participants. In fact, some research suggests that contexts can also provide an incentive for participant to behave truthfully when responding to survey questions (Champ *et al.*, 1997). Likewise, participants must have a good understanding of the attributes, since in the survey they are asked to make trade-off decisions in the choice experiment section. In the second section of the survey the choice experiment is presented to respondents. When comparing to the other sections in the survey, the choice model requires a more involved consideration of preferences on the part of the participants since this section primarily considers trade-offs scenarios. Despite being a shorter survey (expected time of completion was 10-15 min.), it was considered important to present the set of choices early in the survey to avoid completion mistakes due to tiredness. The third section of the survey focuses on measuring the perceived level of responsibilities that landowners and society have to protect wetlands in agricultural areas was presented. This section is shorter, and the time expended in each question of this section is also expected to be lower than the previews. In the last section of the survey respondents were asked to provide a range of demographic information used to help understand the characteristics of the respondents which can be used to contrast the characteristics of the sample population with those of the provincial population as provided by census data. The demographic information can also be used to identify heterogeneity in preferences (see section 5.6). The demographic section was designed to be straightforward, and was not expected to be time demanding. The survey ends with a space to participants openly express they thoughts (if any). Each of the survey sections above are discussed in more detail below.

4.3.1. Attributes description and the choice set

Prior to the Choice Experiment development, an introduction to the wetland degradation in Saskatchewan and the attribute description was presented. The introduction section of the survey is concise since the main purpose is to provide participants with some context but avoiding respondent fatigue and incentives to skip parts of the survey. Nevertheless, some historical information of the wetland degradation is provided as background information. The background

information provided is the drainage loss that has occurred in Saskatchewan due to poor conservation management on wetlands.

As discussed in Chapters 2 and 3, the Choice Model (CM) technique was chosen as the most appropriate to quantify the value of EG&S provided by wetlands in the agricultural landscapes of Saskatchewan. The CM approach involves asking survey respondents to choose their most preferred resource use option from a number of alternatives. The advantages of CM over other non-market valuation techniques (e.g. contingent rating, contingent ranking, contingent valuation method) include the potential to provide a richer data set, strategic bias - reduction, benefit transfer potential, framing effect control and context flexibility (Bennett and Adamowicz, 2001; Do and Bennett, 2007). However, this tool also requires people to respond to a specific hypothetical scenario; therefore, there is an assumption that respondents understood the good in question and answered the survey truthfully. Recently, many techniques have been created to minimize hypothetical bias caused by these assumptions. Techniques that have shown some promise in addressing this problem are *cheap talk* (proposed by Cummings & Taylor, 1999) and *follow up certainty questions* (see Champ *et al.*, 1997). First, cheap talk explicitly states to participants the importance of truthful behaviour during the survey. Many authors found this technique efficient to reduce hypothetical bias (Lusk, 2003; Aadland & Caplan, 2003). Thus, respondents were presented with a cheap talk section. The cheap talk section developed in the survey was based on that proposed by Aadland and Caplan (2006) and Do and Bennett (2007). This section had the objective of reducing hypothetical bias, potentially present on any survey. The cheap talk used in this project is translated below.

"As you prepare to answer the next few questions, please keep in mind that previous surveys suggest that the amounts that people SAY they are willing to pay are sometimes different from the amounts that they would ACTUALLY be willing to pay when conservation options became available in their community. For this reason, please imagine your household is ACTUALLY paying the amount you choose."

In addition to the cheap talk section, a follow up certainty question was included in the survey with the objective of reducing possibilities of hypothetical bias. According to Champ *et al.* (1997), improvement in the results may be acquired if only participants that stated to be

confident are considered in the model estimates. The follow up certainty question consists of providing participants with the opportunity to express how comfortable they were answering the set of choice questions (see appendix B, page 115). Participants were asked to measure how sure they were about their choices on a scale from one (very unsure) to ten (very sure). Participants that chose 4 or below were removed from further analysis and the results from the sample with all participants and "just sure" participants (above 4) were compared (results from this question can be found at section 5.4).

The bundle of EG&S to be valued in this study are those that are provided directly or indirectly by wetlands on Saskatchewan's privately owned agricultural land. Significant wetland attributes pertaining to the Saskatchewan agricultural area were identified in consultation with ecologists and agricultural and environmental economists at the University of Saskatchewan. Importantly however, adding attribute or levels to the model will increase the information available to researchers, but also can make respondents fatigued as they are asked to complete a longer survey, decreasing the quality of the results (Train, 2002). There is no ideal number of levels and attributes. Commonly used in the choice method applications for valuing wetlands, the present study prioritizes a shorter set of choice scenarios and opted for four attributes with different levels. The following attributes were identified as providing the most relevant to the present research.

- Riparian Area: are those areas located immediately beside wetlands, stream and rivers. The option for riparian area as an attribute is mainly due to the importance for providing ecosystem function to wetlands. Research has shown that wider riparian areas can provide greater levels of EG&S such as filtration of soil sediment, pesticides and nutrients from runoff water and wildlife habitat. The levels considered for this attribute in the survey are:
    - *5 metre riparian zone* - vegetated riparian zone: Will provide very limited buffering of sediment, pesticides and nutrients, will provide very limited additional wildlife habitat.
    - *10 metre riparian zone* - vegetated riparian zone: Establishment of perennial grasses in riparian zone to act as a buffer zone to decrease erosion and increase water quality, as well as providing some wildlife habitat.

- *20 metre riparian zone* - vegetated riparian zone: In most cases provides very significant decreases in sediment, nutrient and pesticide entering the wetland and the riparian zone also provides habitat for wildlife.

- Wildlife Population: wetlands are an essential part of the life cycle of many wildlife species found in the agricultural zone of Saskatchewan. The levels for Wildlife population in the survey are:
  - *No action* - with no specific conservation action, the wildlife habitat may continue to be converted to agricultural production and wildlife populations that depend of prairie wetlands may decrease.
  - *Maintenance* - low level of preservation actions would maintain the current level of wildlife population.
  - *High* - high level of preservation actions would increase the current level of wildlife population by 10%.
- Water Quality[15]: A Boil Water Advisory is a public warning stating that the water supplied in a specific location may be unsafe for human consumption. This means that prior to drinking, cooking, or even brushing your teeth, the water must be brought to a rolling boil for a specified amount of time. These advisories are sometimes referred to as Precautionary Drinking Water Advisories. The more serious boil water orders are issued in the event of a water sample testing positive for biological, physical, or chemical contaminants. Examples would be if the coliform count exceeds provincial standards, or if the turbidity levels are too high. These orders are issued when there is a confirmed problem with the water that could pose as a health concern to those consuming it. For example, on March 18th, 2010, Regional Health Authorities and the Saskatchewan Ministry of Environment had 244 boil-water advisories– 183 were precautionary and 61 were emergency boil water orders. The levels for this attribute in the survey are:

[15] As the present date and to our knowledge, boil water advisory has never been used as parameter for water quality standards in wetland studies in Saskatchewan. Nevertheless as public warning of water quality, boil water advisory was found to be measurable, relevant do society, easily communicable. This study understands that boil water advisory satisfactorily fulfill the requirements for a choice model attribute.

- *No change* – current pattern of boil water advisories continue with no anticipated decline and a potential for an increase in boil water advisories in future years.
- *Improve 10%:-* Land and water management actions targeting an increase in water quality as demonstrated by a decrease in boil-water advisories by 10%.
- *Improve 40%:* Land and water management actions targeting an increase in water quality as demonstrated by a decrease in boil-water advisories by 40%.

- Price: representing a one-time payment to compensate the landowners for adopting conservation management. The levels of payment used in this study included $0 (no payment required); $5; $10; $50; $100; $250, and; $500.

The levels of each attribute were also determined in consultation with wetland experts as well as CM experts from the University of Saskatchewan and the Saskatchewan Ministry of Agriculture. To select the payment levels described above, three criteria were used: i) good coverage - the payment vehicle should have applicability and relevance across the studied population; ii) acceptability -the payment vehicle should be widely acceptable to the respondents, and; iii) feasibility - it is not too costly and complicated to implement in a real world application.

A large number of unique wetland management scenarios can be constructed from the selected four attributes and 3 or 4 levels (Louviere, Hensher, & Swait, 2000)[16]. Experimental design techniques and the software *Statistical Analysis System* (SAS) were used to obtain an orthogonal design, which consisted of only the main effects, and resulted in 18 pair-wise comparisons of alternative wetland management scenarios, which generated 9 choice sets. Each set contained two wetland management scenario profiles and an option to select neither scenario. Such an "opt out" option can be considered as a status quo or baseline alternative, since choosing this option implies no change in EG&S provision and payments. The inclusion in the choice sets of an "opt out" option is instrumental to achieving welfare measures that are consistent with demand theory (Louviere, Hensher, & Swait, 2000; Bennett & Blamey, 2001). The respondents were told that if they chose the "opt out" scenario option, there would be no requirement of

[16] The full factorial design for these attributes and levels can be calculated as following: L^A , where L is the number of levels and A is the number of attributes. Thus, since the present study has three attributes with three levels each (3^3) and one attribute with 7 levels (7^1), the total number of possible unique scenarios is 7x27=189.

payment ($0 payment), however there would also not be any active wetland management, in which case the respondent would understand that wetland and EG&S conditions would deteriorate to lower levels for riparian area, wildlife population and water quality attributes. An example of a choice set used in the survey instrument is presented below. The full survey with all nine choice sets is included in this thesis in Appendix B.

Table 4.1. Sample Choice set.

Scenario: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	10 metre	20 metre	0 metre
Wildlife Population 	Low	High	No action
Water Quality 	Improve 40%	Improve 10%	No change
Price 	$10.00	$50.00	$0.00
Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan: TICK ONE BOX ONLY Option A ☐ Option B ☐ Option C ☐			

Source: Results of the present study

4.3.2. Level of responsibility

The attitudes of respondents for level of environmental responsibility were elicited through a series of questions evaluating the respondent perceptions on who should bear the costs of protecting wetlands on privately owned agricultural land in Saskatchewan. However, before measuring the perceived level of responsibility that landowners should bear to preserve wetlands, a question was posed to evaluate participants' attitude towards wetland government policy. This line of questioning was included to capture the perception of the researcher that participants' attitude towards wetland policy could potentially be influenced by the credibility that

government has. A government with low credibility could influence participants interested in wetland conservation to choose options in which landowners have greater level of responsibility. In other words, one could argue that participants' attitude towards wetland government policy could be biased if participants do not believe government is capable of providing the right incentives for protecting wetland through policy instruments. Thus, participants were asked to give their thoughts on government policy on wetlands in Saskatchewan. Participants were asked whether they believe public policy can help landowners to preserve wetlands, and whether government should allocate more money from their budget to improve natural areas and environmental quality. Similarly, they were presented the following two statements and asked whether they strongly agree, agree, disagree or strongly disagree.

a) Landowner have the moral obligation to preserve wetlands on their lands;

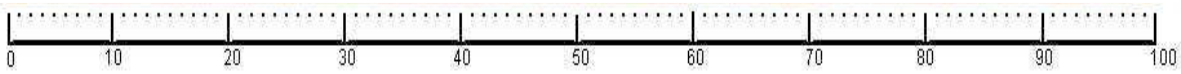
b) Society has the moral obligation to help landowners to preserve wetlands on their land.

The statements above can provide important information about participants' perceived level of environmental responsibility, between society and landowners, of providing EG&S on privately owned land. Participants can then be grouped according to whether they agree or not with each statement. The responses to these questions can be related to demographic characteristics and compared to help identify heterogeneity in preferences. For example, using basic statistical methods (e.g. T-test), it's possible to discern whether sample beliefs differ between groups of people with lower and higher income or education. Regarding whether society or landowners are perceived to have greater responsibility for wetland preservation costs, the results according to the demographic information can have an important impact on policy development, since it's possible to argue that a particular group of people would be most affected by a specific policy change. For example, consider the hypothetical situation where only high income people believe government should allocate more money to wetland conservation policies. In such scenarios perhaps a progressive style environmental tax could be employed to increase the relative responsibility of this societal segment.

To more fully evaluate the perception of participants on relative responsibility for EG&S conservation, participants were presented with a scenario where they are asked to choose the percentage of wetland preservation costs that landowners and society should be responsible for. Similarly, the results from this question can be compared based on the demographic data in order to capture differences in opinion related to specific demographic characteristics. An example can

be the potential difference in opinion between urban and rural population with regard to who should bear most of the conservation costs (landowners or society). The question was framed as follow:

> *"Suppose it is found that it will cost a landowner $100 per acre to preserve a 3 acre wetland on their land. When preserved this wetland can provide the full range of EG&S provided by any healthy wetland. What proportion of that $100 should the landowner be responsible for? Choose a proportion from the following 100 point scale where 100 indicates the landowner should be responsible for all wetland preservation costs while 0 indicates that society, through public conservation payments, would fully compensate the landowner for wetland preservation costs:"*



4.3.3. Demographic information

The last section of the survey focuses on collecting the relevant demographic information. This information is required to assess the quality of the data in term of representativeness of the sample population relative to the general population, as well as to use these data as explanatory variables to investigate heterogeneity in preferences. This section was composed of five questions (see appendix B), designed to provide important information about participants' socio-economic characteristics. The descriptive statistics from this section were firstly compared with the 2006 Canadian census (results are presented in chapter 5, table 5.1), which has the objective of assessing the quality of the data acquired in the survey. Significant differences between census and the survey results could be a source of concern, since statistically similar results are the expected outcome from representative sample. Therefore, it is expected that the majority of the demographic information would not differ significantly from the census data. Once the demographic information from the whole sample is compared with census data, it is possible to use this socio-economic information within specific sub-groups for both the *level of responsibility* and the *choice* analysis (see how the demographic results were coded, compared and how descriptive statistics was conducted in the section 4.4). For example, considering the household income or education information that is collected in the survey, it is possible to

investigate if high income or educated participants present different attitude towards wetland conservation.

Therefore, choosing which socio-economic information to be considered in the study is very important. The Canadian census can give important insights of types of variables that one could use. However, there is a trade-off between number of questions to be included in the survey and difficulty to acquire participants or quality of the data due the fatigue. Therefore, this study gives preference for a short and straight forward demographic section. The variables chosen in the demographic section for this study are commonly used in the vast majority of census and demographic sections of studies employing surveys.

4.4.Delivering the survey

The CE survey was conducted as a web-based survey. Prior to administering the survey it received approval from the ethics committee for human and behaviour research at University of Saskatchewan. Participants voluntarily answered the survey questions which were hosted by the Itracks' web system (www.itracks.com)[17]. A Web-based survey has a number of advantages over other methods of conducting surveys. Cobanoglu *et al.* (2001) found greater response rate and lower cost for web-based surveys when compared to mail and fax methods. Furthermore, web-based survey facilitates relatively rapid data collection, can be widely applied and eliminate hand-coding since data is coded automatically (Cobanoglu, Warde, & Moreo, 2001). The sample size of the present survey was 250 participants, aged 18 years or older, sampled from Saskatchewan residents.

Among the advantages of web-based surveys is the elimination of hand-coding since data is coded automatically. The data was mostly coded as binary variables according to the interest of each analysis made in this thesis. For example, the answer for statement a) (section 4.3.2),

[17] This company was hired to recruit participants and to host the survey on the web. The company was asked to respect the terms of the ethical approval (e.g. ensuring minimum age for participants, anonymously participants recruiting, etc.), which conditioned their hiring process. However, the company did not provided the response rate for this study.

people choosing agree or strongly agree were coded as 1 and all others coded as 0. Therefore, calculating the percentage of people agreeing (or strongly agreeing) that Landowner have the moral obligation to preserve wetlands on their lands, can be easily calculated. Descriptive statistics can also be provided from a binary series. For example, the percentage of the sample that agree or strongly agree with the statement a) can be obtained from a simple average of the binary for those that have chosen these options.

All descriptive statistics developed for the present study were made using the *Eviews* econometric software. Eviews was also used to conduct simple hypothesis tests. Hypothesis tests were often used to statistically compare any multiple series of data. For example, in order to infer whether, the group of people agreeing and strongly agreeing with statement a (section 4.3.2) is different from the number of people disagreeing and strongly disagreeing, a hypothesis test was carried.

Interactions of the demographic information with the questions from the choice experiment section of the survey (presented at 4.3.2) used a similar procedure. However, in this case, the binary variables were multiplied by the demographic information, therefore isolating the demographic information from the group of interest. For example, considering that the household income or education information is collected in the survey, it is possible to investigate if high income or educated participants present different attitudes towards wetland conservation. In order to infer whether people that *believe landowners have the moral obligation to preserve wetlands on their lands* (statement a, 4.3.2) higher levels of income than the average individual in the sample (the results of these examples can be found at section 5.3.1, page 68), the binary variable for agreeing and strongly agreeing with this statement (a) can be multiplied by the income series from the sample (which would isolate only the income of those participants that have chosen either agree or strongly agree options for statement a. Then, the simple hypothesis test can be carried in *eviews* with both the series resulting from this multiplication and the income from the whole sample. *Eviews'* output will give the p-value from this test considering the hypothesis that both series statistically have the same average. All the data from the survey was coded as binary variables and analyzed according to the objectives of this study. The results from each series created, its interactions, and the descriptive statistics are presented in chapter 5 along with their respective discussion.

4.5. Summary of the chapter

Agriculture has been traditionally important to Saskatchewan. However, agricultural development has also been associated with a range of environmental costs. Evidence shows that the majority of wetland losses in the province have occurred within the agricultural landscape. To assess perceptions of this problem, this study developed a survey mechanism focused on agricultural land. A selection of EG&S that are provided by prairie wetlands were identified and a choice model was applied as the method to estimate values for these attributes. The perceived level of responsibility that landowners and society have towards conserving wetlands was also considered through a series of questions during the survey development. The survey was finally delivered using a web-based approach. The results from the methodology presented in this study are discussed in chapter 5.

5. CHAPTER – RESULTS AND DISCUSSION

5.1. Introduction

The previous two chapters have provided the theoretical and research background to EG&S evaluation within agricultural landscapes. The aim of this chapter is to establish the relevance of the theoretical model to the social preferences of Saskatchewan residents in order to provide important information on the value of EG&S for the development of appropriate policies. The chapter analyzes the characteristics of Saskatchewan's society and geographical factors that may affect their participation choice. An investigation was also conducted to evaluate the perceived level of responsibility that landowners and society should bear in any wetland conservation initiatives, as well as social WTP for wetland attributes. This chapter begins with an explanation of the survey results providing a range of descriptive statistics. Following this two different econometric choice models were estimated and compared to evaluate the model's robustness and goodness of fit with the survey data. A discussion of the empirical model results is presented in next section. Finally, the chapter ends with a summary.

5.2. Survey results[18]

Participants in Saskatchewan electronically completed a total of 250 surveys in June 2010. The survey was electronically hosted by the Itracks' web system and available until the completion of 250 surveys[19]. Personal and demographic information from the survey were

[18] Due to nature of the choice set, it is not possible (to the present date) express the descriptive statistics for the attributes considered in the choice model.
[19] The company did not provided the response rate for this study

compared with equivalent parameters from Saskatchewan's 2006 Census to evaluate whether the sample population was representative of the provincial population (Table 5.1). Social and economic characteristics of the sample were mostly not significantly different from the 2006 Census for Saskatchewan. For example, average adult age of the sample doesn't differ statistically from the 2006 census (Statistics Canada, 2006a). The sample was arranged in the range of 18-60 years old for comparison with the census data. Consistent with the Saskatchewan population, most of the participants sampled were within the range 18-60 years old (73%). The overall average age of the sample is approximately 49 years old. The percentage of participants stating their nationality as Canadians was also not significantly different from the 2006 Census data. From the sample, 97% stated to have Canadian citizenship. Moreover, the percentage of participants with university or higher degree and the stated annual average income were not significantly different from 2006 Census (Statistics Canada, 2006a). However, the sample population had a lower representation of rural residents than the provincial population at the 5% significance level. This difference may be expected due to the fact that Internet access is higher in urban areas and in many rural areas that do have Internet access it is relatively slow technology making survey completion frustrating. Despite the difference in rural population, the sample population of this study may be considered representative of the Saskatchewan population, since all other demographic characteristics were similar to the 2006 Census for the province and the difference in rural population was not strong enough to be rejected at 1% significance level.

To more effectively understand the influence of respondent characteristics on the responses the rural population was evaluated in isolation. Since there was statistical difference between the census and the sample results for rural residents (see "*rural population*" in table 5.1), social characteristics of both urban and rural resident characteristics were compared. Comparing these samples may help understanding the reasons for this difference. For example, if rural respondents were statistically older than census' rural population, it may indicate that age was one factor influencing the number of responses in rural area. On the other hand, no statistical difference between the rural characteristics may indicate that despite the rural sample being smaller, the characteristics within the sample doesn't differ from the census. In the case that the demographic characteristics of rural respondents are not significantly different from the census data, there may be an indication for greater confidence with the sample results. From the 250

participants, 71 stated that they were rural Saskatchewan residents. The average age of those participants was approximately 48 years old, which is not significantly different from the average age in rural Saskatchewan according to the census 2006 (table 5.2) (Statistics Canada, 2006b). The level of education on average was also similar to the census of 2006 for rural Saskatchewan (Statistics Canada, 2006b).

Table 5.1. Social and economic characteristics of the respondents (n=250).

	Sample Average (Std. Dev.)[a]	Canada census (2006) - Saskatchewan[b]
Between 18 - 29 years old	25.50% (33.42%)	25.68%
Between 30 - 60 years old	51.79%(49.05%)	49.59%
Over 60 years old	27.1% (44.5%)	24.70%
Canadian Citizen	97.2% (16.5%)	96.80%
Rural Population**	28.40%	35.00%
Education (% with university degree and above)	32.7 (47.0%)	34.00%
Income (Average – CAD$ annually)	44,761 (18,7601)	46,705

Note: *** denote difference with statistical significance at 1% level, ** denote statistical significance at 5% level and * denote statistical significance at 10% level; [a]Original data obtained from the survey of Saskatchewan society; [b]Statistics Canada (2006b).
Source: Results of the present study.

Table 5.2. Social and economic characteristics of the respondents living in rural Saskatchewan (n=71).

	Sample Average (Std. Dev.)[a]	Canada census (2006) - Rural Saskatchewan[b]
Age (average)	48 (18.87)	52
Canadian Citizen	95.8% (20.3%)	-
Average Education	High School/Tech. Diploma	High School/Tech Diploma

Note: *** denote difference with statistical significance at 1% level, ** denote statistical significance at 5% level and * denote statistical significance at 10% level; [a]Original data obtained from the survey of Saskatchewan society; [b]Statistics Canada (2006b).
Source: Results of the present study.

5.3. Level of responsibility

An important component in understanding the perceptions that society holds with respect to how the responsibility for wetland and EG&S conservation should be shared between landowners and society is their attitude towards wetland government policy. For example, if participants do not support government policies, one could argue that their attitudes on the level of responsibility between landowners and society could be biased, since the EG&Ss would be better provided when landowners bear the costs. In other words, a government that has a low level of credibility to the public could influence participants interested in wetland conservation to choose options in which landowners have greater level of responsibility. In fact, some surveyed participants that opt for landowners to manage wetland stated that there is no guarantee that the money would be properly spent if government becomes responsible for bearing the costs[20]. Thus, participants were asked whether they believe public policy can help landowners to preserve wetlands. The results indicate that 75% of the respondents believe public policy can help landowners to preserve wetlands on their land.

After participants were asked about their attitudes toward public policy for wetlands the survey then focused on determining their beliefs on government budget allocation. Results indicated that the majority of the respondents (88%) agreed that government should allocate more money from their budget to improve natural areas and environmental quality in Saskatchewan. In other words, it seems that the majority of the sample population perceived that wetland conservation was not adequately represented in government priorities. However, as discussed earlier (chapter 4) they were not provided with the actual provincial expenditures on wetland programs. This result represented an expression based on their perceptions of government budget allocations (see chapter 4). This position that governments should allocate more budget may be a response to the understanding that there has been 85% wetland loss since early 1800s in Canada. This finding is consistent with other recent research showing that the

[20] The referred statement is fully presented as follows. "*The discussion of dollar values assumes the money would be properly spent. There is no guarantee of that if government gets too involved*". This participant opted for farmers to fully bear the costs of wetland preservation.

public believes that the environment should receive greater attention from policy makers (*e.g.* Olewiler, 2007). Adamowicz (2007) argues that the depreciation of habitat is considered "*significant by the Canadian public*". Furthermore, with respect to the competing priorities of governments, Adamowicz (2007) highlights the fact that the trade-off between maintaining the tax base and protecting natural capital, in addition to the desire to be re-elected, can lead governments to opt for conversion of natural capital to constructed capital, as follows (in Adamowicz, 2007).

> Governments *"are often subject to pressure from developers to convert lands, and the developments erected on these lands serve to improve the tax base. Protecting the natural capital will not provide* [the government] *with tax revenues, and this can create political and economic difficulties for the community."*

The behavioural characteristics of the sample population were further investigated by evaluating the frequency in which respondents participate on nature related activities in Saskatchewan. Hartig, Kaiser and Strumse (2007) argue that people may behave in environmentally friendly ways because they gain psychologically from their experiences in natural environments. Therefore, the present survey presented to respondents the option to choose one of the following categories of participation in nature related activities: a) never; b) less than once in a month; c) 1-3 times in a month, and; d) once a week or more. The number of participants that participated less than once in a month in outdoor activities in rural areas of Saskatchewan (40%) is statistically greater than the number of participants that stated that they participated 1 to 3 times per month of more (23%), which in turn is statistically smaller than the number of those that never participate (37%). Thus, approximately 63% of the sample population participated in outdoor activities in rural Saskatchewan.

These findings are fairly consistent with Jackson (2006), who found that nearly three-quarters of Canadians indicated great or some interest in participating in outdoor activities in natural areas, such as camping, picnicking, hiking, riding, cycling, skiing, snowshoeing, off-road vehicle use, swimming or boating. Regionally, when asked about the participation on recreational services (such as hunting and fishing) Saskatchewan is the province with the highest percentage of households reporting participation (Statistic Canada, 2006). Weaver (1997) and SES (2009) have highlighted the potential for and growth of outdoor activities in rural areas of Saskatchewan. According to a 1991 survey, 19% of Canadians took vacations to engage in non-consumptive wildlife-related pursuits, such as watching or studying wildlife, photography, and

hiking. In addition, many studies show that tourists are willing to pay to experience these natural areas by spending approximately 2.4 billion dollars per year in Canada and 8.5% more for services and products that are provided by environmentally responsible suppliers (SES, 2009). According to Weaver (1997), the Saskatchewan prairies provide a variety of opportunities for ecotourism industry, with special interest for bird watching, where wetlands play a significant role. Moreover, a 1996 Environment Canada survey found that an estimated of 9 million Canadians (38% of the population) participated in residential wildlife-related activities and 4.4 million Canadians (18.6% of the population) participated in wildlife viewing in Canada (Environment Canada 1999, pg.11).

Respondents were also asked how often they participate in nature-related activities in non-rural areas of Saskatchewan, which would include urban parks. The results indicate that there are significantly more people participating in nature-related activities (stating options other than '*never*') in non-rural areas (70%) than rural areas (at 10% significance level). This is an expected result since the majority of the sample population was located in urban areas (Table 5.1). Therefore, one may expect that, simply due to the relatively lower cost of access (e.g. travel time, gas consumption) the percentage of participants using urban facilities for nature-related activities would be higher. As a point of comparison respondents from rural areas were less likely (at 5% significance level) to participate in nature related activities in urban areas with 30% of participants indicating that they '*never*' participate urban area; and 29% chosen the options 1-3 times in a month or more (see table 5.3).

It should be noted that the majority of those that do not often participate in nature-related activities 21% of the total sample would use neither rural nor non-rural areas. On the other hand, 11% of the respondents often participate in both rural and non-rural nature related activities (table 5.3). Overall, the results on table 5.3 show the participants behaviour towards outdoor nature-related activities, which is supported by other studies that highlight the potential of recreational outdoor activities and ecotourism (e.g. Jackson, 2006; DSE, 2008; Statistics Canada, 2006a).

Table 5.3. Nature related activities distribution.

On average, how often do you participate in nature related activities	Rural Average (Std. Dev.)[a]	Non-rural Average (Std. Dev.)[a]	Both Average (Std. Dev.)[a]
Never (%)	37.0 (48.4)**	30.3 (46.0)**	20.7 (40.6)***
Less than once a month (%)	40.2 (49.1)	40.2 (40.1)	19.5 (39.7)***
1-3 times or more in a month (%)	22.7 (42.0)**	29.5 (45.7)**	10.8 (31.0)***

Note: *** denote difference with statistical significance at 1% level, ** denote statistical significance at 5% level and * denote statistical significance at 10% level; [a]Original data obtained from the survey of Saskatchewan society.

Source: Results of the present study.

5.3.1. Public preferences for management responsibilities

To better understand public preferences for policy aimed at providing EG&S the participants' opinions on the relative responsibility of landowners and society with respect to wetland conservation were assessed. First, they were presented the following two statements and asked whether they strongly agree, agree, disagree or strongly disagree.

a) Landowners have the moral obligation to preserve wetlands on their lands;
b) Society has the moral obligation to help landowners to preserve wetlands on their land.

For both statements, the number of respondents that agreed and strongly agreed were significantly higher at the 1% level of significance (see Figure 5.1 and 5.2). In the case of the statement that landowners have a moral obligation, 87% of the participants either agreed or strongly agreed, with less than 13% of the respondents disagreeing with the statement. Interestingly, approximately 81% of the sample also agreed or strongly agreed that society has the moral obligation to help landowners to preserve wetland on their land. At first, these findings may seem to be contradictory; however, a carefully assessment suggest that respondents appear to be supportive of some level of shared cost. The respondents believe that the primary holder of the wetland property rights has an obligation to maintain those wetlands but that the beneficiaries

of a number of the EG&S that flow from those protected wetlands, namely the broader society, has a responsibility to shoulder some of the costs of conservation, even if the conservation occurs on private land. Furthermore, approximately 76% of the participants agreed or strongly agreed with both statements. Participants may prefer a shared cost structure due to the complexity of the goods and services being provided by wetlands since it can represent benefits to both, society and landowners (National Wetlands Working Group, 1988). One concern over the results of the survey may be that the significant difference between the statements a) and b) (87-81= 6%) is coming from the lower concentration of rural population in the sample (demographic difference between 2006 Census and sample data - table 5.1). If that was the case, there could be an indication that the results are biased[21]. To test this hypothesis, the rural population was isolated and both statements (a and b) were compared with the results for the whole sample. The percentage of rural population that agreed and strongly agreed with statements a) and b) (83% and 76%, respectively) does not statistically differ from the whole sample at the 5% significance level. Therefore, similar to the whole sample, there are more people agreeing and strongly agreeing with statement a) than statement b) in the rural population which indicates that the results are not biased in this way. Therefore, even considering a sample with more landowners, the number of respondents agreeing or strongly agreeing with statements a) and b) is not expected to differ from the presented results.

From the perspective of the policy maker, the perceived share of responsibility is very important. Indeed, policies implicitly determine the level of responsibility that landowners and society have over wetland. For example, a regulatory policy may transfer to landowners specific obligations that impose preservation costs (Claassen, et al., 2001). On the other hand, a financial payment instrument may transfer to the landowners the flexibility of choosing what percentage of the costs they may wish to bear (DSE, 2008), but since the sample population agreed that both landowners and society (through public policy) have responsibilities, questions about the perception of the distribution of this shared cost naturally arise. Note that despite agreeing that both landowners and society have moral obligations towards EG&S conservation, little is known about how this responsibility is shared. For example, how should the costs of protecting wetlands

[21] This hypothesis assumes that the sample with fewer landowners wouldn't have power enough to push the results towards greater society responsibility - considering they would present a more selfish behavior. In this case, it would be considered *selection bias* (or selection effect), in which all participants are not equally balanced or objectively represented.

be shared, between the landowner and the broader public, according to social perceptions? For example, landowners may agree that they have responsibilities over EG&S provision, but they may also argue that their level of responsibility is low and public policy should bear most of the costs.

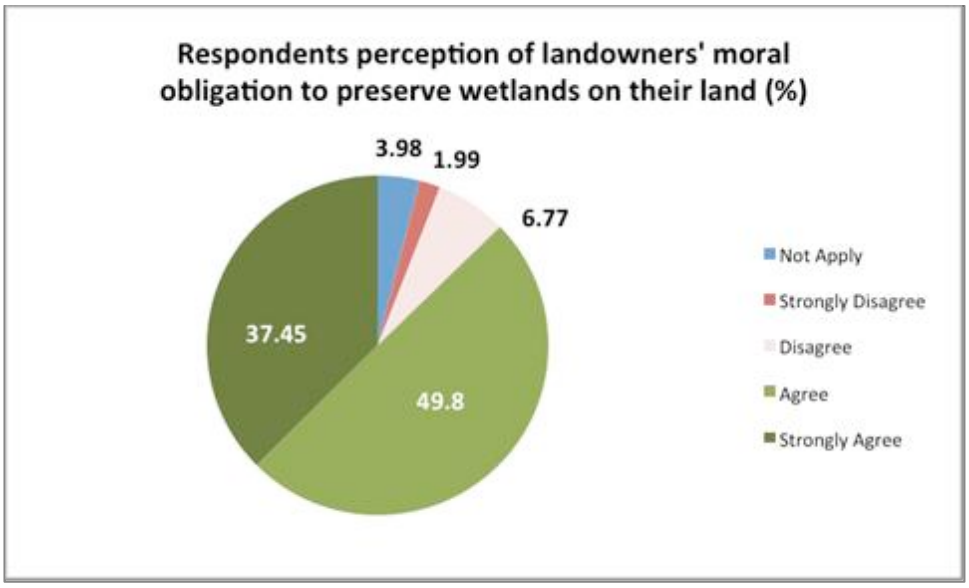


Figure **5.1. Respondents perception of landowners' moral** obligation to preserve wetlands on their land.
Source: Results of the present study.

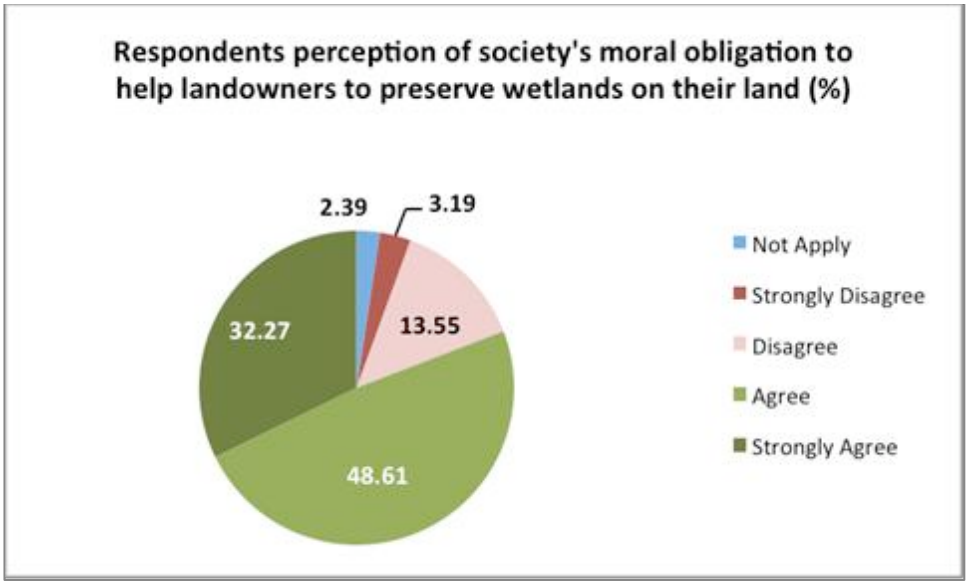


Figure **5.2. Respondents perception of society's moral ob**ligation to help landowners to preserve wetlands on their land.

Source: Results of the present study.

In an attempt to more completely understand the level of sharing of responsibility and conservation costs between landowners and society, participants were asked to choose the percentage of costs that landowners should be responsible for, assuming that the rest would be supported by society through public policy (Figure 5.3). Within this sharing structure a response of 0% means society would be fully responsible for the costs to protect wetlands through public policy instruments, and a response of 100% means that landowners would fully bear the costs of wetland preservation. The most frequent response (30% of respondents) was a 50-50% share, which means that approximately one third of the participants agree that society (through public policy) and landowners should equally split the costs of protecting wetlands on privately owned land (Figure 5.3). This result is significantly (at 1% significance level) higher than any other share. To better understand the implications for policy of this result the characteristics of the individuals that chose this equal share alternative where isolated. The average age of these participants is less than the sample average (significant at 1%) suggesting that age influences respondents' choice for equal sharing of the conservation costs, such that younger respondents are more likely to choose 50-50% share. In contrast, the level of education and income doesn't statistically differ from the total sample results (table 5.4). In short, respondents that preferred 50-50% share are younger, with average education and income (compared to the whole sample data).

Respondents can also be distinguished in the group in which society was felt to be responsible for a greater share (0%-40% share for landowners) and the group in which landowners have greater share (60-100%). Considering these groups, the majority of the sample was distributed within the group of people believing society should be responsible for a greater share (50.6% of the respondents). In other words, most participants prefer the cost sharing structure in which society bears over 50% of the conservation costs. Interestingly, most of the participants in the sample are from urban areas of Saskatchewan, which may be an indication that (participants believe) society should bear a greater level of responsibility over EG&S provision through public policy than landowners. While the survey responses were not specifically developed to determine the range of reasons participants had for choosing the level of responsibility for the provision of environmental services some of the potential reasons are

implied by responses given by respondents to the open ended question. For example the following perceptions were provided that may form the foundation for the level of responsibility reported: i) the belief that public policy may not be efficiently helping landowners; ii) landowners cannot have additional costs added to their costs structure: "*farming is not a lucrative business to be in", and* iii) the nature of the good being provided (public). Furthermore, compared with the averages from the sample population, the group of participants who feel that society should shoulder a greater share of the costs for conservation (0-40% share) represented higher annual income (average annual income of 47,047 - significantly different from the sample average at 10%) and greater education university degree or above (38.78%, significant at 5%). However, respondent age did not statistically differ from the total sample average age. These results suggest that wealthier and more educated people would likely prefer policy measures that distribute the level of responsibility of wetland conservation towards society. Considering these results together, over 80% of the participants felt that society should be responsible for 50% or more of the conservation costs.

The group of participants that felt that landowners should bear most of the conservation costs was significantly smaller (19% of the sample). This group of people presented average age but had an annual income that was smaller than the sample average (46 years old and 41,326, respectively - both significantly different at 1%). This result may be an indication that lower income people are less willing to see their money expended on wetland conservation. Such suggestion could be supported by some of the reasons participants gave for lower societal responsibility for the costs in the open ended question (e.g. "*farm is a business (...) and businesses have to reduce a bit of profit to accommodate environmental*"). However, identifying the reasons people had to choose the sharing costs structure is beyond the scope of this study.

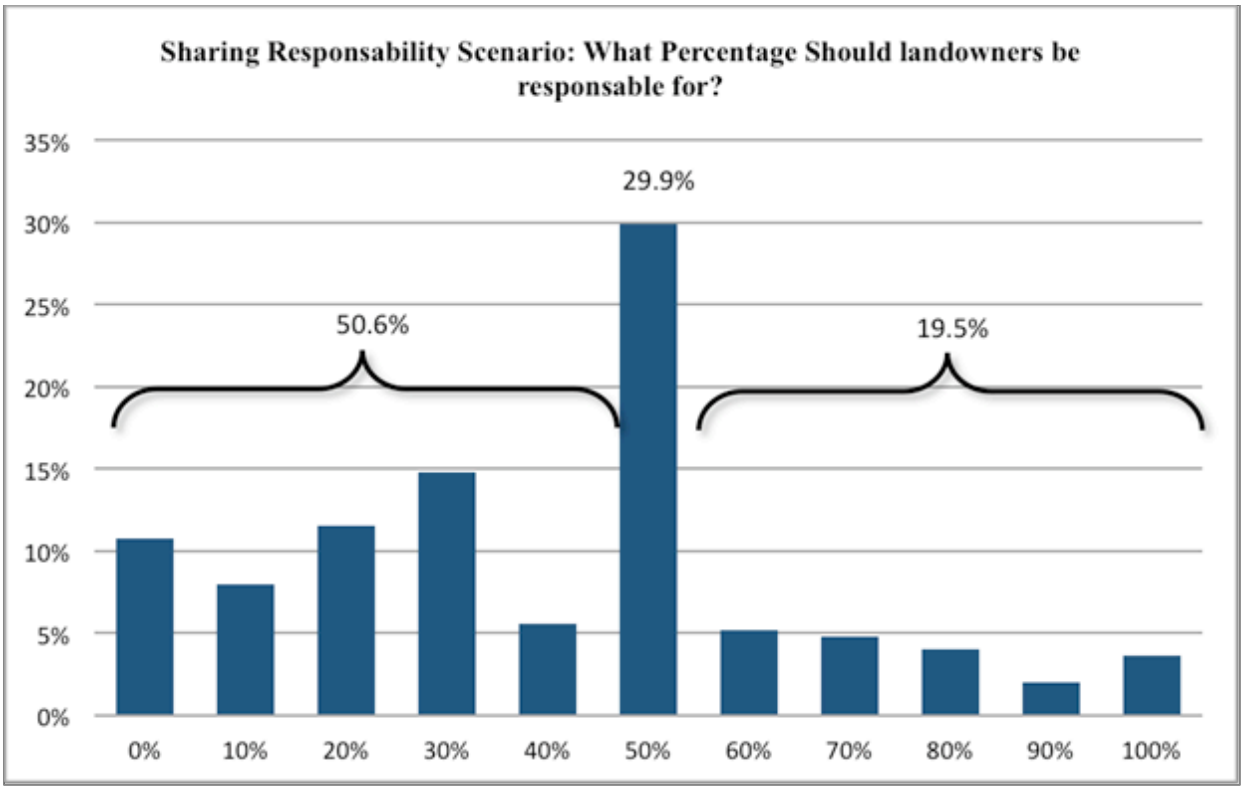


Figure 5.3. Perceived sharing responsibility scenario

Source: Results of the present study.

As indicated earlier, the respondents stated a preference for the option to share equally the responsibility for wetland conservation with approximately 30% of all respondents choosing this option. This result may be subject to a level of bias with the respondents not having well-developed preferences and choosing the easiest option to justify. In addition, if the majority of people preferred 50-50% share, one would expect a normal distribution of the preferred proportion of sharing centered on 50-50. The normal distribution was tested (details of the testing methods included in Chapter 4); however, the hypothesis of normal distribution was rejected. Indeed, the majority of the respondents (51%) chose societal responsibility while only 20% chose landowners' responsibility. Rural residents presented similar behaviour: 33% of the rural residents opted for 50-50 sharing cost; 53% chose societal responsibility and 14% of rural respondents felt that landowners' should be responsible.

Despite the above discussed concerns, overall the results were deemed to be a satisfactory representation of population perspectives and appeared to be in agreement with the related

literature. A negative correlation was found between age, education and income and the preferred level of responsibility for landowners. Thus, on average, older, more educated and wealthier participants prefer a greater level of responsibility for society. The significant difference between the three share groups' variables (age and income) and the sample averages may indicate that different social levels may have different preferences with respect to the environment and EG&S in Saskatchewan.

Table 5.4. Social and economic characteristics of the respondents within perceived shared cost groups

	Lower landowner responsibility (0-40% share)	Equal Sharing (50-50% share)	Greater landowner responsibility (60-100% share)	Total Sample
Age	50.4	46.4***	45.9***	49.3
Education (% with university degree and above)	38.8%**	32.0%	30.7%	32.7%
Income	47,047*	43,133	41,326***	44,761

Source: Results of the present study.

5.4. Valuation of wetland EG&S

As discussed in chapter 3, the CE was designed based on the assumption that the observable utility function would follow a strictly additive form. The model was specified so that the probability of selecting a particular wetland management scenario was a function of attributes of that scenario and of the alternative specific constant (ASC – see chapter 4), which was specified to equal 1 when either management scenario A or B was selected, and to 0 when the 'neither management scenario' option was selected. Using the 2250 choices elicited from 250 respondents, two basic conditional logit (CL) models (McFadden, 1974; Greene, 1997 pp. 913–914; Maddala, 1999, pp. 42) with logarithmic and linear specifications for the attributes at three levels were estimated and compared using the LIMDEP/NLOGIT statistical software. The highest value of the log-likelihood function was found for the specification with both three-levelled attributes in linear form (reported in Table 5.5). Thus, the logarithmic specification was not considered a good fit and only the results from the linear specification are relevant for (and used in) this study (*e.g.* Birol, Karousakis, & Koundouri, 2006). In addition, the model was specified considering both the total number of participants and including only those participants who indicated they were sure about their responses (using cut off 4 – see section 4.3.1) and the results of these two analyses were compared. However, no statistical differences were found in the coefficients considering the results from the follow up certainty question. In other words, the number of participants unsure about their choices wasn't large enough to significantly affect the results. For this reason, only the whole sample was considered in this analysis. The results from the CL model[22] are reported in the first column of Table 5.5. The coefficients for CL model are highly significant, at 1% level of confidence, and all the signs are as expected a priori according to utility theory.

The analysis of the survey results indicates that the respondents felt that all of the wetland attributes are significant, and *ceteris paribus*, higher levels of any single attribute increases the probability that a management scenario is selected. In other words, respondents prefer scenarios that result in higher levels of riparian area, wildlife population and water quality. The negative sign on the payment coefficient indicates that higher payment levels decrease the utility of

[22] From this point further CL model will only refer to the linear specification.

selecting that choice set. The negative sign of the payment coefficient also can be interpreted that higher levels of payment would reduce the probability that a management scenario is selected, *ceteris paribus,* which is expected (Do & Bennett, 2007). However, the interpretation of the coefficient values is not straightforward (except for the significance and relative size).

For further interpretation of the coefficients it is necessary to calculate the marginal rates of substitution between the attributes using the coefficient for cost as numeraire, which is considered as average marginal WTP. Overall, these results indicate that positive and significant economic values exist for higher levels of ecological attributes of the wetland. The positive and significant sign on the ASC coefficient implies that a positive utility impact occurs in any move away from the status quo. In other words, any improvement made on the current levels of wetland conservation is preferred by participants holding other variables constant. This result is also expected, since it indicates that participants care about EG&S provided by wetlands and improvements are welcome, *ceteris paribus*. Indeed, the positive correlation between the movement away from the status quo and the increase in utility is not uncommon in wetland valuation studies. Examples of preference for wetland management scenarios over *status quo* include, Do and Bennett (2007) estimating wetland biodiversity values in Vietnam's Mekong River Delta found positive ASC coefficient; Whitten and Bennett (2005) found similar results in southern Australia and Birol *et al.* (2006) in Cheimaditida, Greece.

Table 5.5. CL, RPL and RPL with interactions estimates for wetland management attributes[23].

Attributes	CL	RPL		RPL model with interactions
	Coef. (s.e.)	Coef. (s.e.)	Coef. Std. (s.e.)	Coef. (s.e.)
Alternative Specific Constant (ASC)	1.70880*** (0.0855)	0.01324*** (0.0458)	0.3275*** (0.0337)	-0.23294 (0.1760)
Riparian area	0.23500*** (0.0334)	0.21363*** (0.0381)	0.07046* (0.0390)	0.34718*** (0.0408)
Wildlife Population	0.38186*** (0.0386)	0.30236*** (0.0394)	0.07364* (0.0399)	0.15527*** (0.0422)
Water Quality	0.63839*** (0.0414)	0.57080*** (0.0424)	0.12993*** (0.0434)	0.32134*** (0.0484)
Payment	-0.00355*** (0.0003)	-0.00169*** (0.0002)		-0.00212*** (0.0002)
RA*Age				-0.00065 (0.0029)
WP*Age				0.00572** (0.0028)
WQ*Age				-0.01709*** (0.0029)
RA*Education				-0.05309 (0.0464)
WP*Education				0.16165*** (0.0443)
WQ*Education				-0.33038*** (0.0508)
RA*Income				-0.00349 (0.0137)
WP*Income				-0.01063 (0.0132)
WQ*Income				0.01419 (0.0152)
Log likelihood	-1904.250	-4142.15		-3496.15
AIC	1.82093	1.31844		1.11593
BIC	1.83440	1.32380		1.13094

Note: *** denote statistical significance at 1% level, ** denote statistical significance at 5% level and * denote statistical significance at 10% level.

Source: Results of the present study.

[23] Due to nature of the choice set, it is not possible (to the present date) express the descriptive statistics for the attributes considered in the choice model.

The CL model assumes the independence of irrelevant alternatives[24] (IIA) property, which states that the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives. If the IIA property is violated then CL results will be biased and hence a discrete choice model that does not require the IIA property, such as random parameter logit (RPL) model, should be used. To test whether the CL model is appropriate, the Hausman and McFadden (1984) test for the IIA property is employed (see details in chapter 3 and Appendix C)[25]. The procedure is, first, to estimate the model with all choices. The alternative specification is the model with a smaller set of choices. Thus, the model is estimated with this restricted set of alternatives and the same model specification. The set of observations is reduced to those in which one of the smaller set of choices is made. In order to compute the coefficients in the restricted model, it is necessary to drop those observations that choose the omitted choice(s) (Greene, 2002). The results of the test are shown in Table 5.6 (below). As a result, in this test, Scenario A, B and C consider 1, 2 and 3 alternatives as restricted model, respectively. Therefore, observations choosing 1, 2 and 3 alternatives are marked as bad data and excluded in scenarios A, B and C, respectively. The Hausman statistic is used to carry out the test. In the preceding example, the large value suggests that the IIA restriction should be rejected (Greene, 2002). The large Chi-Squared value also suggests that IIA restriction should be rejected[26]. Rejecting IIA allows the use of a more flexible model with a the RPL (Louviere, Hensher, & Swait, 2000). That is, on the basis of the Hausman-McFadden test the constant variance assumption has been violated and a less restrictive specification of the choice model needs to be considered. Therefore, the RPL model is appropriate for estimation of this data.

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[24] Detailed explanation of IIA and the Hausman-McFadden test can be found at Appendix C.
[25] The Hausman-McFadden IIA test was also executed using LIMDEP 8.0 NLOGIT 3.0.
[26] Hausman and McFadden (1984) provide a table for the cumulative distribution function of the test statistics, which is used by LIMDEP 8.0 NLOGIT 3.0 to calculate the probability value presented in table 5.6. Such procedure resulted in probability values extremely low (<0.05), suggesting that the restricted model is likely different from the non-restricted. In other words, the relative probabilities of two options being chosen are likely affected by the introduction or removal of other alternatives.

Table 5.6. Test of Independence of irrelevant alternatives.

Alternative dropped	ChiSqrd	Probability
Scenario A	33.48	.000003
Scenario B	57.55	.000000
Scenario C	17.54	.000546

Source: Results of the present study.

5.5. Accounting for heterogeneity in wetland attribute valuation

Within the CL model, homogeneous preferences are assumed across all respondents. Preferences are in fact heterogeneous and accounting for this heterogeneity enables estimation of unbiased estimates of individual preferences and enhances the accuracy and reliability of estimates of demand, participation, marginal and total welfare (Greene, 1997). Furthermore, accounting for heterogeneity enables prescription of policies that take equity concerns into account. An understanding of who will be affected by a policy change in addition to understanding the aggregate economic value associated with such changes is necessary (Boxall & Adamowicz, 2002). The random parameter logit (RPL) model (Train, 1998), which accounts for unobserved, unconditional heterogeneity, such as the wetland studied in this CE, should be used in order to account for preference heterogeneity in pure public goods (Kontoleon, 2003).

Recent research has shown that applications of the RPL model are superior to the CL model in terms of overall fit and welfare estimates (Layton & Brown, 2000; Carlsson *et al.*, 2003; Kontoleon, 2003; Lusk *et al.,* 2003; Morey & Rossmann, 2003; Birol, Karousakis, & Koundouri, 2006).

Thus, the RPL model is estimated using LIMDEP/NLOGIT software. All the parameters except the payment attribute were specified to be normally distributed (Train, 1998; Morey & Rossmann, 2003; Carlsson, Frykblom, & Liljenstolpe, 2003; Birol *et al.*, 2006). The results of the RPL estimations are reported in the second column of Table 5.5. The coefficients obtained by

the RPL model are similar to the CL model. All of the wetland EG&S attributes are significant factors in the choice of a wetland management scenario, and *ceteris paribus*, higher levels of any single EG&S attribute increases the probability that a management scenario is selected. The payment variable is negative, indicating that higher payment levels decrease the utility of selecting that choice set. Finally, the null hypothesis that the parameters of the regression are equal is rejected by the log-likelihood ratio test (at 0.5%), which suggests that RPL is appropriate for analysis of the data set.

Allowing parameter to randomly vary over individuals, RPL accounts for heterogeneity in the choice. However, this model fails to explain the sources of heterogeneity (Boxall and Adamowicz, 2002). Birol *et al.* (2006) suggest that sources of heterogeneity can be detected by including socio-demographic interactions with choice specific attributes and/or with ASC in the utility function. Such procedure would enables the RPL model to pick up preference variation in terms of both unconditional taste heterogeneity (random heterogeneity) and individual characteristics (conditional heterogeneity), and hence improve model fit (Birol *et al.,* 2006).

Many models are possible to be considered from the interaction of socio-demographic information and attributes choices. The model presented in the Table 5.5 is a result of extensive testing of the various interaction possibilities. Thus, the model that includes education, income and age was found to provide the best fit to the data. This model also has a better overall fit compared to the RPL model based on results from the log-likelihood (LL = -3496.15, which represent an improvement from RPL model without interaction, LL= -4142.15). To test if the regression parameters of these models are in fact equal, the log-likelihood ratio test was implemented (Greene, 2002). As expected, this test enables the rejection of null hypothesis that the regression parameters for the RPL model and the RPL model with interactions are equal at 0.5% significance level, suggesting that improvement in the model fit is, in fact, achieved with the inclusion of social and economic characteristics.

Similar to the model with no interactions, the coefficients for riparian area, wildlife population, water quality and payment remained significant and with the expected signs. Therefore, higher levels of any single EG&S attribute increases the probability that a management scenario is selected. Also similar to the model with no interaction, the payment variable is negative, indicating that higher payment levels decrease the utility of selecting that choice set. However, ASC presented negative sign, indicating that positive utility impact exists

in any movement towards status quo. Nevertheless, the coefficient is not significant. The interactions between age, education and wildlife population are positive. Confirming the results of several environmental valuation studies (Birol, Karousakis, & Koundouri, 2006; Do & Bennett, 2007), those respondents with higher levels of education are likely to prefer wetland management scenarios that provide higher levels of wildlife population. The interaction of riparian area and age, education and income was not significant, thus; these population features are likely to have little effect on riparian area conservation choice[27]. Similarly, the interaction between the income and wetland attributes is insignificant, suggesting that wetland attribute choice is unaffected by respondents' income, similar to Birol, *et al.* (2006).

5.6. Estimation of willingness to pay

The CE method is consistent with utility maximisation and demand theory (Bateman, et al., 2003). When the parameter estimates are obtained by the use of the appropriate model, welfare measures, in the form of marginal willingness to pay (WTP), can be determined by estimating the marginal rate of substitution between the change in the wetland management attribute in question and the marginal utility of income represented by the coefficient of the payment attribute.

The implicit prices, or marginal WTP values, for each of the wetland management attributes was estimated using the Wald procedure (Delta method) in LIMDEP/ NLOGIT (Table 5.8). For comparisons, estimates were calculated using CE and RPL models (Greene, 2002). T-tests of WTP estimates of each attribute reveal that the WTP estimates from the models differ significantly at 1% significance level or less (except for the WTP for the Riparian area attribute from the CLM and RPL models, differ at 5% significance level). The numbers expressed in Table 5.8 represent the amount that a household would be willing to pay, in a one-time payment, for 1 level increase in the attributes. Thus, societal WTP (RPL) for increasing riparian area from

[27] The result from the interaction between income and the attributes would, more likely, be expected to have stronger influence on level of attributes. The argument is that people with less income would be less willing to pay for EG&S than people with higher income, but that is not what suggest the results of this study.

5 to 10 meters is estimated at CAD$ 64.73; for wildlife population level[28] increase, society is willing to pay CAD$ 57.56, and; for water quality, society WTP for decreasing the frequency of boil water advisories is CAD$ 104.68. However, the comparison with these values needs to consider the details of the location in which the study took place, since the range of wetland prices (values) in the literature can vary from US$.15 per hectare ($ 0.06 per acre) to US$54,485 per hectare ($ 22,050 per acre)[29] (Brander, Florax, & Vermaat, 2006). Considering a more local range, table 5.7 presents estimated values for restoring natural areas in some area of Canada.

Table 5.7. Estimated values of EG&Ss provided by wetland

	Description	Value	Location
WTP	fish and wildlife habitat by non-users	$267 - $453/person/yr	Alberta
WTP	freshwater fishing	$97/person/yr	Lake St.Clair
WTP	hunting and fishing	$400 /person/yr	Alberta
Cost	Water Quality - removing phosphorus	$21.85 - $61.20/kg	Vancouver's primary and secondary waste treatment plants
Cost	Water Quality - removing nitrogen	$3.04 - $8.50/kg	Vancouver's primary and secondary waste treatment plants
Net Value	conserving or restoring natural areas	$195/ha/yr	Grand River Watershed of Ontario
Net Value	conserving or restoring natural areas	$65/ha/yr	Upper Assiniboine River Basin in eastern Saskatchewan and western Manitoba
Net Value	conserving or restoring natural areas	$126/ha/yr	Mill River Watershed in P.E.I.
Net Value	Recreational Benefits - wildlife viewing	$53.45/ha/yr	Fraser River Valley, BC
Net Value	Flood protection from wetlands	$408 - $2,110/ha/yr	Fraser River Valley, BC
Net Value	Hunting and fishing	$36/ha/yr	Fraser River Valley, BC
Net Value	All EG&Ss provided by wetlands	$5,792 - $24,330 /ha/yr	Fraser River Valley, BC

Source: Adapted from Olewiler (2004).

The results from the present study put Saskatchewan in context with table 5.7. In other worlds, Saskatchewan residents seem to be within the range of values for wetland EG&S provision observed in other studies across Canada. Nevertheless, this study's results provide important implications for EG&S and wetland policy development. The fact that water quality improvements had the greatest WTP in both models is a strong indication that participants recognise greater value in improvements in water quality. From a policy perspective, providing incentives to farmers to provide water quality on their wetlands will have more appeal to society and, it's likely to be a better option. According to the graphical framework presented in section

[28] For a complete description of the wildlife population and water quality levels please see section 4.4.1.
[29] In a meta-analysis of wetland valuation studies, Brander, Florax and Vermaat (2006) found that these studies are diverse in terms of values estimated. In fact, they found that of 33 wetland valuation studies done over 26 years the values per acre has ranged from US$ 0.06 to US$ 22,050 (Brander, Florax, & Vermaat, 2006).

3.2, it is possible to conclude that the externality associated with wetland changes that negatively impact water quality is greater than the other attributes. Thus, to provide society with the necessary amount to shift their marginal benefits to socially optimal levels of water quality, it is necessary more money (according to the formula presented earlier, $MB_p^s = MB_p^p$ + externalities) than the other attributes. Despite the fact that calculating the precise curve for the marginal benefits provided by wetland (or wetland attributes) is beyond the scope of this study, it is possible to precisely measure the amount needed to shift the current marginal benefit curve to the optimal. These are the amounts presented in the table below.

Based on survey data the social value of water quality is expected to be higher than the others attributes. The provision of clean water is an issue of worldwide importance and the role of wetlands in providing water quality is increasingly recognized by society and policy makers. Other wetland studies also presented water quality as one of the main concerns of society (e.g. Huel, 2000). However, the different models used in the present research provided different rankings for wildlife population and riparian area as EG&S attributes of wetlands. According to the characteristics of the model (see section 3.4), it could be possible that the unobserved factor from participants choosing riparian area is lightly correlated to wildlife habitat. For example, it could be possible that some participant have identified riparian area as a condition to increase in wildlife population. In this case, the RPL would be more appropriate (more detail about correlation in error term can be found at section 3.4.2). If the error terms from wildlife population are correlated to riparian area, only the RPL would capture this relationship.

Table 5.8. Marginal WTP for wetland management attributes (one-time payment, CAD/household/level increase) and 95% C.I.

Attributes	CLM (CAD)	RPL (CAD)
Riparian area**	66.11	64.73
Wildlife Population***	107.42	57.56
Water Quality***	179.59	104.68

Note: T-test show significant differences among the models (*) at 10% significance level; (**) at 5% significance, and (***) at 1% significance level.

The implicit prices reported in Table 5.8 do not provide estimates of compensating surplus (CS) for the alternative management scenarios. In order to estimate the respondents' CS for improvements in wetland management over the status quo, three possible options were created.

• Current scenario — Perceived current levels of Riparian area, wildlife population and water quality.

• Scenario 1 — Low impact management scenario: Riparian area of 10 metre; wildlife population increased by 5%; water quality remain the same.

• Scenario 2— Medium impact management scenario: Riparian area of 20 m; wildlife population increased 10%; water quality remain the same.

• Scenario 3 — High impact management scenario: Riparian area of 20 m; wildlife population increased 20%; water quality improved 40%.

To find the CS associated with each of the above scenarios the difference between the welfare measures under the status quo and the three management scenarios are calculated. Note that in order to estimate overall WTP for wetland management it is necessary to include the ASC, which captures the systematic but unobserved information about respondents' choices. The estimates of WTP for the three scenarios are reported in Table 5.9 below. For comparisons, CS estimates are calculated for all models. The numbers expressed on table 5.9 represent the amount that society should be compensated for a decrease in wetland management scenario in order to maintain indifference. In other words, society WTP (RPL) for scenario 1 is CAD$ 15.52; for up-grading from scenario 1 to scenario 2, society is willing to pay CAD$ 25.15 more (40.67), and; for moving from status quo to scenario 3, society WTP is CAD$ 134.57.

Table 5.9. Compensating Surplus for each scenario (CAD/respondent).

Scenario	CLM	RPL
Scenario 1	24.15	15.52
Scenario 2	63.28	40.67
Scenario 3	209.36	134.57

Source: Results of the present study.

As expected, the CS for the change from the status quo to the scenarios considered increases as we move towards improved ecological conditions in the wetland. For the CLM the mean WTP for the Low impact scenario is CAD$ 24.15, whereas greater improvements in ecological conditions in the wetland under the Medium impact scenario increase mean WTP to CAD $63.28, and under the High impact scenario to as high as CAD $209.36.

Note that the difference between scenario 1 and 2 (RPL $25; CLM $39) is smaller than the difference between 2 and 3 (RPL $96; CLM $146). Comparing the specification for each scenario and the WTP for attributes (table 5.8), it's possible to conclude that much of this difference reflects the greater concern that participants had with wildlife population and water quality. Thus, the results from this study suggest that when considering wetland preservation in Saskatchewan agricultural areas, participants would most likely prefer policies that provide water quality. Similarly, Laporte, Weersink and Yang (2010) highlight the importance of meeting water quality objectives for conservation policies in Ontario.

5.7. Summary

The demographic characteristics of the sample population were statistically insignificant from the general population, as represented in Census information from 2006 with the only exception being the rural population, which was further assessed. Overall, the comparison of sample results with the Census information indicated that the demographic characteristics of the sample population was consistent with the general population. Following the analysis of demographic information, the perceived level of responsibility that participants had towards the environmental costs of protecting EG&Ss provided by wetlands in agricultural areas of Saskatchewan was assessed. The results showed that the perceived level of responsibility was significantly higher for a sharing structure that consider 50-50 of the preservation costs being split between landowners and society. Other than equally splitting the costs, participants preferred costs structure that had society having greater responsibilities than farmers. In addition, these results were interacted with the demographic information in order to find heterogeneity in

behaviour. For instance, the education level and income of the participants that opted for levels of responsibilities towards society were found to significantly higher than the total sample. Finally, the results from the Choice Model were presented. From the attributes, water quality presented the highest WTP. Therefore, it is considered the most important attribute to participants. Following the WTP calculation, management scenarios where different levels of EG&S would be provided, were simulated. These results are expected and in agreement with the literature. Overall, the results from the interaction of the survey data with the model were satisfactory.

6. CONCLUSION

The economic integration between natural and managed ecosystem is a growing area of interest to agricultural policy makers. The literature explored in Chapter 2 highlighted some of the EG&S provided by wetlands; the problems related to properly defining property rights, and; some of the valuation tools and methods available to help policy development. The development of effective policy to ensure efficient provision of EG&S is hampered by a poor understanding of the preferences and values of EG&S held by farmers and society. Specifically in the province of Saskatchewan, it appears that little information is available to help policy makers ensure wetlands are conserved within privately-owned farmland. Economic valuation plays a role in assisting wetland management and informing policy development through the process of estimating the value to society. It acts to capture the economic values of benefits wetlands provide and to support the wise use of wetland resources.

A choice model is a tool that can be used to provide important valuation information for EG&S provided by wetlands located in privately owned agricultural land. This information is important for designing effective economic incentive policy. The choice model assumes an underlying rational decision process and that this process has a functional form. Depending on the behavioural context, a specific functional form may be selected as a candidate to model that behaviour. This study considered the logit distribution in two different models as an approximation of the human behaviour towards utility maximization, which is consistent with the random utility theory (RUT). The models considered were the conditional logit model and the random parameter logit model. These models are used to understand the difference in utility when choices are made, and it assumes that people will choose the option that provides then greater utility. The main difference between these models is the underlying assumptions of the preferences. The conditional logit model would not allow error terms from one alternative to be correlated with error terms from other alternative. This assumption is a result from the specification of the model which provides the model with a nicely closed form. However, it is

possible that in some situations the assumptions from the condition logit may not be best suitable. Thus, a more flexible model was considered, the RPL. The RPL allows errors to be correlated by considering parameters as random. With this model, it was possible to satisfactorily estimate participants' willingness to pay for EG&S attributes associated with wetlands in Saskatchewan.

A web-based survey was delivered to a sample of Saskatchewan residents. The survey was mainly composed by three sections, the choice set, the level of responsibility measures, and demographic information. The EG&S related attributes found to be most relevant for participants when considering wetlands were riparian area, wildlife population, water quality, and payment. The survey was answered by 250 participants, aged 18 years or older, sampled from the list of Saskatchewan residents.

As indicated by the results, respondents felt that all of the wetland EG&S are significant factors in the choice of a wetland management scenario. In other worlds, results suggest that Saskatchewan residents care about the EG&S provided through wetland conservation. In addition, higher levels of any single attribute increases the probability that a management scenario is selected, *ceteris paribus*. Respondents prefer those wetland management scenarios which result in higher levels of riparian area, wildlife population and water quality. Water quality was the attribute that had the greater concern. People were willing to pay higher amounts for increasing the water quality. Indeed, the results from management scenarios presented in this study suggest that when considered wetland preservation in Saskatchewan agricultural areas, participants would most likely prefer policies that provide water quality. This is an important finding that has direct effect in policy development.

It also important to consider that the majority of participants preferred a sharing cost structure where landowners and society would equally split the costs of conserving wetland. This finding also has direct implication for policy development. According to the methodology applied in the circumstances considered in this study, it is possible to conclude that a wetland policy in Saskatchewan would be more suitable for society if a cost structure in which society bear most part of the cost up to 50-50 is employed. Overall, this study is expected to help inform policy makers by quantifying the value of some of the society's preferences towards EG&S provision in Saskatchewan.

6.1.Final considerations

Despite its complexity in design and data analysis, CM has demonstrated its advantage of providing rich data set. By using CM, one can derive not only WTP for one overall change program but also WTP for each wetland attribute and multiple other overall change strategies. This helps wetland managers to prioritise the use of available resources for wetland management. Also, CM enables the inclusion of not only wetland biophysical attributes but also conservation program's socioeconomic impacts on local households. Therefore, the value estimates derived from CM are more helpful to decision makers because the values are derived in the context of the trade-off between environmental protection and development.

However, the present study also presented some limitations. Even though the sample was compared to Census of Agriculture data and was shown to be broadly representative of Saskatchewan's society, examination of surveys from two hundred and fifty respondents might not be complete enough to make implication about all society. Likewise, considerable heterogeneity may occur if agricultural regions are compared. Studies could be conducted over different landscapes to capture the impact of various biological characteristics such as climate, soil productivity and precipitation and economic behaviour. Although CM can be applied in Saskatchewan context to estimate nonmarket values of wetland, further research on issues such as questionnaire design and survey method is needed.

Indeed, there are many opportunities for future research of policies for EG&S preferences . The initial attempt this study made for valuing the cost-share for incentive payment needs more research. Wetland quality determines the function and variety of ecological services provided and therefore requires equivalent attention when wetland conservation policies are established. Three wetland attribute were considered, however; wetlands provides a complex vast amount of EG&S, which might be considered for a more comprehensive set of information when developing conservation policies. Further, understanding the relationship between wetland quality and its functions would assist decision makers to better target wetlands that yield greater environment benefits with fixed budget. Lastly, wetland valuation research should be

investigated from all sides of the wetland market. Currently, the majority of economic research has focused on quantifying society's valuation of the goods and services wetlands provide from the demand side of the market using valuation study to estimate society's WTP. However, valuation from the supply side may be much more important due to its decisive role in wetland quantity and quality management and thus, there should be more work to develop it, such as some resent studies developed in Australia (e.g. Stoneham *et al.,* 2003).

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Appendix A

Consent Form

University of Saskatchewan

Research Supervisor: Dr. Kenneth Belcher (306)966-4019, ken.belcher@usask.ca, Department of Bioresource Policy, Business and Economics 51 Campus Drive , Saskatoon, SK, S7N 5A8

Student Researcher: Mr. Vitor Dias (306) 966-4039 vitor.dias@usask.ca, Department of Bioresource Policy, Business and Economics 51 Campus Drive, Saskatoon, SK, S7N 5A8

You are invited to participate in a research project entitled *Values of Ecological Goods and Services for Policy development in Saskatchewan.* Please read this form carefully, and feel free to ask questions that you might have.

Purpose and Procedure: From a government policy perspective, the purpose of this study is to estimate the value of Ecological Goods and Services on an agricultural landscape of this province, to the people of Saskatchewan. We are asking that participants act as truthfully as possible in a survey where the demand of Ecological Goods and Services is targeted. The estimated time to complete the experiment is 10-15 minutes.

Potential Benefits: Your participation will increase the understanding around the priorities of Ecological Goods and Service provision policy for the province of Saskatchewan.

Potential Risks: There are no known risks associated with participating in the survey. All data will be stored in a safe and secure manner and all information will be confidential.

Storage of Data: The researcher will store all data collected in a safe and secure manner at the Department of Bioresource Policy, Business and Economics for a period of five years. The data will be destroyed, after 5 years, when it is no longer required.

Confidentiality: The research conclusions will be published in a variety of formats, both print and electronic. The survey process does not enable a link between respondent identity and responses. These materials may be further used for purposes of conference presentations, or

publication in academic journals, books or popular press. In these publications, the data will be reported in a manner that protects confidentiality and the anonymity of participants. The information provided by survey participants will be used and presented in aggregate without individual responses being reported.

Right to Withdraw: Your participation is voluntary, and you can answer only those questions that you are comfortable with. The information that is shared will be held in strict confidence and discussed only with the research team. You may withdraw from the research project for any reason, at any time during the survey answering process, without penalty of any sort. If you withdraw from the research project, any data that you have contributed will be destroyed at your request. However, after the survey is completed, you may not be able to withdraw due to the inability of identifying your survey.

Questions: If you have any questions concerning the research project, please feel free to ask at any point; you are also free to contact the researchers at the numbers provided if you have other questions. This research project has been approved on ethical grounds by the University of Saskatchewan Behavioural Research Ethics Board on (date:). Any questions regarding your rights as a participant may be addressed through the Ethics Office (966-2084). Out of town participants may call collect.

Consent to Participate:

I have read and understood the description provided; I have had an opportunity to ask questions and my/our questions have been answered. I consent to participate in the research project, understanding that I may withdraw my consent at any time. A copy of this Consent Form has been given to me for my records.

☐ I agree

☐ I do not agree

Appendix B

Choice Experiment Survey Instrument

Choice Experiment Survey

Department of Bioresource Policy, Business and Economics

VALUES OF ECOLOGICAL GOODS AND SERVICES FOR POLICY DEVELOPMENT IN SASKATCHEWAN

Values of Ecological Goods and Services for Policy Development in Saskatchewan

This survey has been developed to help determine the importance of Ecological Goods and Services (EG&S) in the agricultural regions of Saskatchewan. EG&S are the benefits arising from healthy ecosystems. These benefits accrue to all living organisms, including animals and plants, as well as humans. Examples of Ecological Goods: clean air and abundant fresh water; examples of ecological services: purification of air and water, and maintenance of biodiversity and habitat for wildlife.

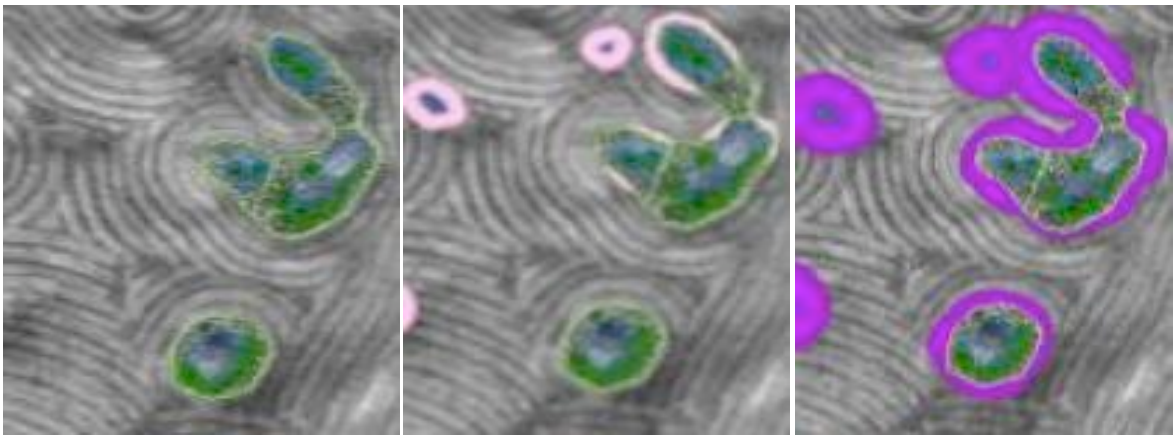
This survey is focused on some of the EG&Ss provided by wetlands and the vegetated riparian areas around the wetlands on agricultural land. In Saskatchewan, wetlands historically covered up to 23% of the land area, but it is estimate that 50-70% of these wetlands have been lost or altered, primarily due to agricultural drainage and cultivation. However, the adoption of environmentally friendly management practices by farmers can help maintain or even increase the EG&S provided. For example, polices that give incentives to farmers to revegetate riparian areas (those areas beside wetlands, streams and rivers) can promote increases in wildlife populations and water quality improvement.

The purpose of this research is to value some of the EG&S that wetlands may provide to society. Thus, the information collected from this survey can be used to better manage some of Saskatchewan's natural resources.

The first section of the survey focuses on your attitudes and values concerning the EG&S provision

You will be presented with different EG&S scenarios and will be asked to choose ONLY one option (A, B or C). It is important that you the option that is most acceptable to you. However, before choosing alternatives, it is important to understand what they represent. Consider:

- Riparian Area: are those areas located immediately beside wetlands, streams and rivers. The riparian area can be measured according to the closest distance from the water surface to the agricultural land. Science has shown that wider riparian areas can provide greater levels of EG&S such as filtration of soil sediment, pesticides and nutrients from runoff water and wildlife habitat. Consider the diagram below, which show wetland areas within a cultivated field, as examples of different levels of riparian area.



- *0 metre riparian zone* - Agricultural practices (e.g. cultivation, grazing) on agricultural fields go right to the wetland edge resulting in soil erosion and release of pesticides and nutrients directly into the water.
- *5 metre riparian zone* - vegetated riparian zone: Will provide very limited buffering of sediment, pesticides and nutrients, will provide very limited additional wildlife habitat.
- *10 metre riparian zone* - vegetated riparian zone: Establishment of perennial grasses in riparian zone to act as a buffer zone to decrease erosion and increase water quality, as well as providing some wildlife habitat.
- *20 metre riparian zone* - vegetated riparian zone: In most cases provides very significant decreases in sediment, nutrient and pesticide entering the wetland and the riparian zone also provides habitat for wildlife.

➢ Wildlife Population: wetlands are an essential part of the life cycle of many wildlife species found in the agricultural zone of Saskatchewan.

- *No action* - with no specific conservation action, the wildlife habitat may continue to be converted to agricultural production and wildlife populations that depend of prairie wetlands may decrease.
- *Maintenance* - low level of preservation actions would maintain the currently level of wildlife population.
- *High* - high level of preservation actions would increase the currently level of wildlife population by 10%.

➢ Water Quality: A Boil Water Advisory is a public warning stating that the water supplied by a specific location may be unsafe for consumption. This means that prior to drinking, cooking, or even brushing your teeth, the water must be brought to a rolling boil for a specified amount of time. These advisories are sometimes referred to as Precautionary Drinking Water Advisories. The more serious boil water orders are issued in the event of a water sample testing positive for biological, physical, or chemical contaminants. Examples would be if the coliform count exceeds provincial standards, or if the turbidity levels are too high. These orders are issued when there is a confirmed problem with the water that could pose as a health concern to those consuming it. Regional Health Authorities and the Saskatchewan Ministry of Environment have 244 boil-water advisories (as of March 18th, 2010) – 183 were precautionary and 61 were emergency boil water orders.

- *No change* – current pattern of boil water advisories continue with no anticipated decline and a potential for an increase in boil water advisories in future years.
- *Improve 10%:-* Land and water management actions targeting an increase in water quality as demonstrated by a decrease in boil-water advisories by 10%.
- *Improve 40%:* Land and water management actions targeting an increase in water quality as demonstrated by a decrease in boil-water advisories by 40%.

➢ Price- Consider that you will be required to provide a one-time payment to help pay for a conservation program. The payment can range from $0 (when there is absolutely no conservation action) to $500 (when some kind of more significant action or change will be implemented).

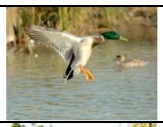
- Choice Set -

Please, consider the scenarios below

As you prepare to answer the next few questions, please keep in mind that in previous surveys suggest that the amounts that people SAY they are willing to pay are sometimes different from the amounts that they would ACTUALLY be willing to pay when conservation options became available in their community. For this reason, please imagine your household is ACTUALLY paying the amount you choose.

Scenario 1: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	10 metre	20 metre	0 metre
Wildlife Population 	High	High	No action
Water Quality 	No change	Improve 40%	No change
Price 	$250.00	$500.00	$0.00
Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan TICK ONE BOX ONLY Option A ☐ Option B ☐ Option C ☐			

Scenario 2: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	5 metre	20 metre	0 metre
	No action	High	No action

Wildlife Population 			
Water Quality 	No change	Improve 10%	No change
Price 	$50.00	$100.00	$0.00

Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan:

TICK ONE BOX ONLY

Option A ☐

Option B ☐

Option C ☐

Scenario 3: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	10 metre	20 metre	0 metre
Wildlife Population 	Low	High	No action
Water Quality 	Improve 40%	Improve 10%	No change
Price 	$10.00	$50.00	$0.00

Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan:

TICK ONE BOX ONLY

Option A ☐

Option B ☐

Option C ☐

Scenario 4: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
	20 metre	5 metre	0 metre

Riparian Buffer 			
Wildlife Population 	Low	No action	No action
Water Quality 	No Change	Improve 40%	No change
Price 	$5.00	$100.00	$0.00

Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan:

TICK ONE BOX ONLY

Option A ☐

Option B ☐

Option C ☐

Scenario 5: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	10 metre	5 metre	0 metre
Wildlife Population 	No action	Low	No action
Water Quality 	No Change	Improve 10%	No change
Price 	$500.00	$250.00	$0.00

Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan:

TICK ONE BOX ONLY

Option A ☐

Option B ☐

Option C ☐

Scenario 6: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	20 metre	10 metre	0 metre
Wildlife Population 	Low	No action	No action
Water Quality 	No change	Improve 10%	No change
Price 	$100.00	$250.00	$0.00

Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan: TICK ONE BOX ONLY

Option A ☐

Option B ☐

Option C ☐

Scenario 7: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	5 metre	10 metre	0 metre
Wildlife Population 	Low	No action	No action
Water Quality 	No change	Improve 10%	No change
Price 	$10.00	$50.00	$0.00

Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan: TICK ONE BOX ONLY

Option A ☐

Option B ☐

Option C ☐

Scenario 8: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	20 metre	5 metre	0 metre
Wildlife Population 	No action	High	No action
Water Quality 	Improve 40%	Improve 10%	No change
Price 	$250.00	$500.00	$0.00
Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan: TICK ONE BOX ONLY Option A ☐ Option B ☐ Option C ☐			

Scenario 9: Suppose options A, B and C are the ONLY ones available			
The following factors will vary under different management options	OPTION A	OPTION B	OPTION C
Riparian Buffer 	20 metre	5 metre	0 metre
Wildlife Population 	No action	High	No action
Water Quality 	Improve 10%	Improve 40%	No change
Price 	$10.00	$5.00	$0.00
Indicate which of the above options (A, B or C) would you prefer to have in the province of Saskatchewan: TICK ONE BOX ONLY Option A ☐ Option B ☐			

Option C	☐

This second section is concerned about some of your responses and thoughts during the last section

1. How sure are you of the choices you made above? Please circle one number from 1 to 10, with 1 indicating "very unsure" and 10 indicating "very sure".

   1 2 3 4 5 6 7 8 9 10

   very unsure very sure

   If you are unsure, please indicate why.

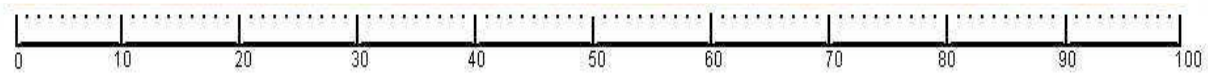
   _____

2. Please rate these statements based on the extent to which they reflect your attitudes toward conserving natural areas.

	Strongly Disagree	Disagree	Agree	Strongly Agree	No Opinion
a) Landowners have moral obligation to preserve wetlands on their land	1	2	3	4	N
b) Society has the moral obligation to help landowners to preserve wetlands on their land	1	2	3	4	N
c) Government should allocate more money from their budget to improve natural areas and environmental quality	1	2	3	4	N
d) Public policy cannot help environmental improvement	1	2	3	4	N

3. Suppose it is found that it will cost a landowner $100 per acre to preserve a 3 acre wetland on their land. When preserved this wetland can provide the full range of EG&S provided by any healthy wetland. What proportion of that $100 should the landowner be

responsible for? Choose a proportion from the following 100 point scale where 100 indicates the landowner should be responsible for all wetland preservation costs while 0 indicates that society, through public conservation payments, would fully compensate the landowner for wetland preservation costs.:



4. On average, how often do you participate in nature-related activities in Saskatchewan? Please circle the number(s) that apply

In Rural areas	In Non-rural areas (e.g. urban parks)
1. Never 2. Less than once a month 3. One to three times a month 4. Once a week or more	1. Never 2. Less than once a month 3. One to three times a month 4. Once a week or more

We would like to ask a few questions about your household. These questions are necessary to help us understand how people feel about these issues

5. Gender: ☐ Female ☐ Male

6. How old are you?

   Answer: _____ years

7. Nationality: ☐ Canadian ☐ Other:_____

8. Where is your home?

   ☐ Rural, farm

   ☐ Town (less than 5000 people)

   ☐ Urban (5000 people or more)

9. Please indicate the highest level of education you have completed
   Circle one number

   1. Elementary school (grades 1 to 8)
   2. High school (grades 9 to 12)
   3. Trade school or technical college
   4. University
   5. Graduate degree

10. What was your total annual household income last year, before taxes?
    Please circle one number

1. $0 - $10,000	2. $10,001 - $20,000	3. $20,001 - $30,000
4. $30,001 - $40,000	5. $40,001 - $50,000	6. $50,001 - $60,000
7. $60,001 - $70,000	8. $70,001 - $80,000	9. $80,001 - $90,000
10. $90,001 - $100,000	11. Over $100,000	

If you have any other comments or concerns about this survey, please feel free to write them in the space below.

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If you have any questions about this survey please contact Vitor Dias at (306) 9664039 or vitor.dias@usask.ca

THANK YOU FOR TAKING THE TIME TO PARTICIPATE IN THIS SURVEY.

Appendix C

Test of Independence from Irrelevant Alternative

Test of IIA

To decide if the IIA property is satisfied in an application, it is necessary to implement a test to establish violation of the condition. The standard test of IIA was proposed by Hausman and McFadden (1984), and is available in choice model statistic software (e.g. NLOGIT 8.0). This test is based on a comparison of the tested model and its restricted forms. According to Greene (2002), the test first estimates a model with all alternatives. The specification under the alternative hypothesis of IIA violation is the model with a smaller set of choices, estimated with a restricted set of alternatives and the same attributes. The set of observations is reduced to those in which one of the smaller sets of choice was made. The test statistic is (Greene, 2002):

$$q = b_u - b_r{}'[V_r - V_u]^{-1}[b_u - b_r] \qquad \text{(C.1)}$$

Where 'u' and 'r' indicate unrestricted and restricted (smaller choice set) models and V is an estimated variance matrix for the estimates.

There is a possibility that restricting the choice set can lead to a singularity. When you drop one or more alternatives, some attribute may be constant among the remaining choices (Greene, 2002). Thus, you might induce the case in which there is a 'regressor' which is constant across the choices. In this case a singular Hessian will result. Hausman and McFadden (1984) suggest estimating the model with the smaller number of choice sets *and* a smaller number of attributes. There is no question of consistency, or omission of a relevant attribute, since the attribute is always constant among the choices, variation in it is obviously not affecting the choice. After estimation, the subvector of the larger parameter vector in the first model can be measured against the parameter vector from the second model using the Hausman statistic (equation C.1). This possibility arises in the model with alternative specific constants, so it is a common case (Greene, 2002). The counterpoint to this advantage, of course, is that, when IIA fails, this test do not provide as much guidance on the correct specification to use instead of logit (Train, 2002).

However, if IID assumption is violated, MNL estimates might be bias; therefore, trigging the use of nested logit, mixed logit (e.g. random parameter logit), and latent class models

detailed in Louviere *et al.* (2000), Layton (2000) or Revelt and Train (1998), and Boxall and Adamowicz (2002), respectively. To introduce respondent heterogeneity, socioeconomic variables are used as independent variables in explaining the probability of choice (Do and Bennett, 2007). These models have been widely applied in estimating wetland values (Do & Bennett, 2007; Whitten & Bennett, 2005; Birol, Karousakis, & Koundouri, 2006).