Farmer Perceptions of Wetland Ecosystem Goods and Services

by

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This thesis is dedicated to everyone working toward climate justice.

Table of Contents

List of tables

List of Figures

Abstract

Wetlands provide services to humans through ecological functions including water filtration, flood prevention, freshwater provision *etc*. Farmers risk losing these essential services as a result of wetland drainage. Wetlands have been established as valuable ecosystems through the economic study of ecosystem goods and services (EGS). However, in comparison to monetary valuation studies, which dominate research, few studies have examined non-monetary values such as human perceptions. *In situ,* unstructured interviews taking place near wetlands were used to examine farmers' perceptions of wetland EGS on farms in the Annapolis Valley, NS. Three wetland types were used and each farmer was interviewed twice to test whether perceptions varied by wetland type and season. Analysis suggests that different wetland types elicit discussion about different EGS. The results of the qualitative analysis do not closely align with monetary valuations and could be used to inform more efficient extension programs towards better wetland conservation on farms.

List of Abbreviations Used

ALUS - Alternative Land Use Services

BMP - Best Management Practices

DNR - Nova Scotia Department of Natural Resources

DUC - Ducks Unlimited Canada

EFP - Environmental Farm Plan

EGS - Ecosystem Goods and Service

EHJV - Eastern Habitat Joint Venture

MA - Millennium Ecosystem Assessment

NSFA - Nova Scotia Federation of Agriculture

PES - Payment for Ecosystem Services

TEEB - The Economics of Ecosystems and Biodiversity

UNEP - United Nations Environmental Program

WTP – Willingness-to-pay

WTA – Willingness-to-accept

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Chapter 1 Introduction

1.1 Problem Statement

Canada, along with many other jurisdictions, has lost many wetlands since European settlement (Wilson, 2000) with some areas experiencing losses as high as 90% (Ducks Unlimited Canada, 2010). When a landscape loses wetlands, it also loses the functions provided by wetlands. Wetland ecosystems provide services to humans such as flood mitigation, nutrient removal, water storage, recreation and others (Crumpton, Kovacic, Hey, & Kostel, 2005; DeLaney, 1995; Ducks Unlimited Canada, 2014; Herath, 2004; Schindler et al., 2014; Vymazal, 2007). Farmers depend on many of these services for efficient farm operations, albeit not all equally or directly. Services from wetlands also extend beyond the farm and contribute to societal well-being in similar ways, such as increasing regional biodiversity and improving water quality. Services associated with the natural functions of wetlands can be conceptualized as Ecosystem Goods and Services (EGS), "the direct and indirect contributions of ecosystems to human well-being" (Sukhdev et al., 2010, p. 33). The Framework for Ecosystem Goods and Services (Millennium Ecosystem Assessment, 2005) provides a useful tool to organize and account for these benefits and allow humans, including farmers, to take stock of the value of healthy and intact ecosystems.

The creation or restoration of wetlands has been advocated by conservation groups (Ducks Unlimited Canada, 2014) and government agencies (Newell, 2010), motivated in part by concerns about diminishing ecosystem services from declining wetland areas. However, farmers are often motivated to eliminate wetlands by ditching or draining to maximize arable land as they face pressures of rising costs and reduced profits (Nova Scotia Federation of Agriculture, 2010). In Nova Scotia, this began with the arrival of the Acadians in 1604 (Griffiths, 2004; Ross, 2002) who used novel technologies to drain salt marshes and reduce salt-water intrusion through the use of dykes and aboiteaux (one way passages that allow water out of but not into the dyked areas)(Bleakney, 2004). Later, inland wetlands became the focus of drainage efforts (Bleakney, 2004), leading to a reduction in freshwater wetland area, especially in the Annapolis Valley, which was sought-after farmland for its fertile growing conditions and well-drained soils.

Estimating wetland loss in Nova Scotia since pre-settlement conditions is difficult. Topography-based analysis of a portion of the Valley near Bridgetown showed that wetland losses since European settlement may have been around 42% as of the early 1980s, but there is considerable uncertainty surrounding the estimate (Kessel-Taylor, 1983). It is possible that the Valley has had a history similar to other agricultural areas of Canada that have experienced losses of 85% in southern Ontario (Ducks Unlimited Canada, 2010; Walters & Shrubsole, 2005) and 80% in the Fraser Valley, BC (Lands Directorate, 1986).

In Nova Scotia, the conversion of wetlands to other land uses is regulated through the Nova Scotia Wetland Conservation Policy (2011). The government-wide policy was mandated in the Environmental Goals and Sustainable Prosperity Act (2007) and has four policy objectives:

- To manage human activity in or near wetlands with the goal of **no loss** in Wetlands of Special Significance and the goal of preventing **net loss** in area and function for other wetlands;

- To promote wetland protection and stewardship and to increase awareness of the importance of wetlands in the landscape;

- To promote a long-term net gain in wetland types that have experienced high historic losses in order to restore beneficial ecosystem services and functions across the province;

- To encourage the use of buffers to better ensure the integrity of wetland adjacent to development (*i.e.* residential, commercial, industrial) and agricultural, mining and forestry operations.

(Nova Scotia Department of the Environment, 2011, p. 9)

Since 2009 and the introduction of the Draft Wetland Conservation Policy, there has been concern from the agricultural community (J. Brazner, Pers Comm., November 2013). The concern derives at least in part from fear that the new policy would hinder farmers' ability to effectively manage their land. Since the policy was approved and adopted in September 2011, there have been no applications for wetland alterations from farmers (as of Nov. 18, 2013, J. Brazner, Pers. Comm.). It is unlikely that farmers were not making alterations to wetlands during this period. In fact one of the wetlands examined for this thesis, an open marsh, was altered during the study. Such an alteration requires an approval under the *Activities Designation Regulations* of the Environment Act (2011). The lack of applications suggests that some farmers are circumventing the regulations associated with the Wetland Conservation Policy. Other industries such as forestry work under different regulations that include a minimum 20 m set-back around open-water wetlands and watercourses (Rideout, 2012).

The Wetland Conservation Policy also acknowledges the importance of voluntary conservation by encouraging stewardship by farmers. In Nova Scotia there is a growing body of research on stewardship behaviour by farmers (e.g. Atari, Yiridoe, Smale, & Duinker, 2009; Goodale, 2013; Sherren & Verstraten, 2013) but few papers focus on wetlands. The one study that did focus on wetlands (Sherren & Verstraten, 2013) was exploratory and made no distinction between different wetland types. Farmers may interact differently with different wetland types, so a more detailed understanding of these relationships is necessary. Furthermore, the Sherren and Verstraten (2013) study was based on a single visit, like most elicitation work, which may lack robustness and the ability to monitor seasonal shifts in perceptions or to assess overall perceptions. Without these insights, government regulators and wetland conservation groups lack the required information to effectively "promote stewardship and increase awareness of the importance of wetlands in the landscape" (Nova Scotia Department of the Environment, 2011, p. 9), especially where financial incentives are lacking. It is important to address this gap in our understanding of farmers' stewardship attitudes toward wetlands in order to create a comprehensive conservation scheme and successfully achieve the goals of the Wetland Conservation Policy.

1.2 Study Purpose

The purpose of this study arises from a lack of knowledge about the social factors that influence the effective implementation of the NS Wetland Conservation Policy. The Environmental Goals and Sustainable Prosperity Act outlines 21 goals for the province of Nova Scotia, to be achieved by the year 2020. As of the 2012 progress report, 14 out of 21 goals had been achieved, including the development of a policy preventing the net loss of wetlands. However, even though goals may be achieved at the policy, regulatory or legislation level, it is unclear if these goals are leading to the intended consequence of EGSPA: "[Nova Scotia] having one of the cleanest and most sustainable environments in the world" ("Environmental Goals and Sustainable Prosperity Act," 2007 4(1)(a)). In conjunction with policy and regulatory approaches, voluntary conservation and stewardship have the potential to help achieve the goals of EGSPA and other similar legislation. As voluntary programs become more important tools in accompanying environmental policy (Kotchen, 2013; Prakash & Potoski, 2012), the importance of understanding farmer motivations to participate in these programs becomes increasingly important.

Several hypotheses exist about farmers' motivation to engage in conservation behaviours. Economic factors (Dixon, Cass, Vincent, & Olfert, 2014; Khaledi, Weseen, Sawyer, Ferguson, & Gray, 2010), social factors (Bandiera & Rasul, 2006; Vanclay, 2004; Vanclay & Lawrence, 1994), education (Fielke & Bardsley, 2014; Huddart-Kennedy, Beckley, McFarlane, & Nadeau, 2009) and experience (Jasinski & Haley, 2014) have all been proposed as motivating factors for farmer engagement in conservation schemes, however none seem to comprehensively explain farmer behaviour. Moreover, factors that motivate farmers toward conservation behaviours may be regionally and culturally specific and hence, not likely to be directly transferable to the Nova Scotia.

To best foster wetland stewardship and achieve ‘no-net loss’, it is critical to understand the perceptions of NS landholders towards wetlands and the EGS they provide. Therefore the purpose of this research is to document the perceptions of farmers toward wetlands within the agricultural landscape and how that varies by wetland type and season. The secondary purpose of this research is to show how these farmer-perceived values may differ from the economic and ecological values of wetland EGS. Finally, the management implications of these farmer perceptions will be explored.

1.3 Research Questions

The problem statement and study purpose guide the research project and provide justification for answering the broad question “how do farmers perceive wetlands?” This overarching question will be addressed through five specific research questions:

1. Which EGS categories do farmers associate with wetlands?
    a. Do farmer perceptions of EGS vary by wetland type?
    b. Do farmer perceptions of EGS vary seasonally?
2. Do the dominant wetland EGS perceived by farmers differ from those based on economic valuation?
3. What are the management and policy implications of farmer perceptions of wetland EGS?

1.4 Outline of Thesis

This thesis is divided into five chapters. The first is this thesis introduction and provides the impetus for the project as well as the research questions driving the project. The second chapter provides background on the research topic and presents relevant literature from disciplines that have informed and enriched the project. Chapter three highlights the methodological approach. The fourth chapter is a stand-alone manuscript intended to be submitted to a peer-reviewed, academic journal. This chapter deals contains the research associated with all research questions. Chapter five is a brief conclusion to the thesis.

1.5 Positionality Statement

This statement discloses factors that affect the way I view the world and way in which I conduct research about it. Being forthright about my own position does not completely eliminate my biases but it does make them explicit. Here I describe how my values and personal development have affected my research and inspired me on the route that I have chosen.

I was born in a middle-class household to white parents of British decent. Although this fact makes me the same race as all the participants in my study, we do not all share the same cultural background. As a child, I lived in Southern Ontario in the wealthy suburb of Toronto called Aurora. I spent much of my childhood taking advantage of its outdoor opportunities. Aurora is surrounded by farmland, however, I was not directly exposed to farming life. I cannot trace my ancestors to farming for several generations and none of my childhood friends were from farms. Growing up in the suburbs has not prevented me from holding strong opinions of agriculture, however. As a child, I was taught that good food came from close by, based on my parent's reverence. My parents held local food in high regard, thus, I learned that the vegetables bought from the Rouge Valley[1] on my mother's route home from work were special because of where they were grown. The Rouge Valley farms in Scarborough, Ontario didn't just produce food, they also served as a barrier to the encroachment of Toronto onto the rural areas surrounding it. In my opinion, farmland is a relatively benign land use compared with the shopping malls, parking lots and subdivisions that much of Greater Toronto has become. I believe that a city with a dense core, low sprawl and an agricultural periphery can give rise to vibrant communities that are easily serviced by effective transit and can feed themselves. I see agriculture as a vital part of a sustainable future for all these reasons.

Along with its positive contributions to sustainability, I am also aware that agriculture can cause serious environmental problems. Issues related to water quality (and quantity), and carbon emissions arising from this industry, need to be addressed. Doing so while maintaining the financial viability of farms is a challenge. As the managers of huge tracts of land in every country on every continent (with the exception of Antarctica), farmers have a key role in implementing change towards more sustainable production. I believe farmers' knowledge and perceptions are

[1] The Rouge Valley is northeast of Toronto. It is currently mostly agricultural but urban development is a constant threat due to its proximity to Toronto and natural beauty.

crucial in understanding how to strike a balance that allows for viable farms and promotes healthy food production in a local context. Unfortunately, I have found that studies on farmer perceptions are rare in the scholarly literature, especially in Canada.

During early stages of investigation into my thesis topic, several dominant concepts and narratives within the relevant body of literature have motivated me. One that I embrace has been the concept of Ecosystem Goods and Services. Although the concept is anthropocentric and for this reason does not totally reflect my thoughts about the environment, I think it raises important questions. It asserts that humans depend on the environment and that the environment has a value to humans, thus making it worthy of conservation. Concepts such as EGS are 'boundary concepts' that facilitate interdisciplinarity and can be used to bridge the traditional disciplinary gaps between quantitative and qualitative (Abson et al., 2014; Star & Griesemer, 1989). Boundary concepts not only facilitate interdisciplinarity but also need interdisciplinarity to thoroughly investigate.

One of the dominant narratives related to EGS is monetary valuation. The argument has been made that conversion to monetary values makes the function of wetlands measurable and understandable and thus giving ecosystem functions the same priority as bottom-line financial imperatives (Costanza et al., 2014). However, the evidence for this is merely implied. While ecosystem service valuation (economic valuation of EGS) is widely used and affecting policy is often a stated goal, examples of effective integration of ecosystem services valuation are almost nonexistent

(Laurans, Rankovic, Billé, Pirard, & Mermet, 2013). This could be partially because the link between science and policy is often obfuscated by political motives and resulting policies are designed to be palatable to the public rather than true to the motivating scientific study. It could also be because many of the public values are cultural and thus poorly captured by economic valuation. For instance, Jacobsen and Thorsen (2010) posit that stakeholder preferences relating to ecosystem function (in this case, marginal benefits in ecosystem function due to the creation of Denmark's first national park) involve more than just environmental preferences. The authors show that cultural factors are important in stakeholder decision-making processes, but not valuation, suggesting that the weak link between policy and ecosystem service valuation may be justified, (see also, Carpenter et al., 2009; Laurans et al., 2013). Filling this gap and improving the way in which ecosystem functions are used to inform policy will require alternative valuation methods that are better equipped to assess cultural services and services provided to non-human inhabitants of ecosystems.

I also believe that the assertion that the monetization of ecosystem services makes them easily comprehendible is tenuous. Around the world, financial illiteracy is widespread – and worsening (Lusardi & Mitchell, 2011). A 2007-2008 United States national survey of financial literacy showed that high school seniors (grade 12) answered only 48% of questions correctly (Mandell, 2008). This represented a 10-point reduction in average scores from ten years earlier, coincidentally the same year that Costanza et al. (1997) published their first study on the value of the world's ecosystem service. I believe that a translation of natural ecosystems to monetary values can create false confidence and can actually lead to worse outcomes for the environment (Willis, 2008).

The marketization risks of monetary valuation are also undeniable. Criticisms of the ecosystem services concept have suggested that valuation could lead to a mass sell-off of nature (Schröter et al., 2014), while non-monetary valuation exercises may not. For example, monetary valuation could result in the liquidation and loss of wetlands through neo-liberal schemes of credits and trading (Brown & Lant, 1999; Gardner, 1996; Robertson, 2004). Additionally, I am concerned about the effect that scarcity could have in increasing ecosystem values as depletion of resources continues. Wetlands provide a case in point. Between the two extensive valuation exercises conducted by Costanza et al. (1997; 2014) the global area of wetlands decreased 43% while the unit value saw a nearly 7 fold increase in value (Costanza et al., 2014). I believe these values ignore a significant part of the lived experiences humans have as they interact with and depend on natural ecosystems, very little of which is market-based.

I have a strong personal research interest in alternative valuation methods that consider values outside of monetary terms and avoid the perils of monetization. Even though it is an extremely complex process I believe that financial valuations lead to a simplified outcome that is far from total value. This is not least because most cultural EGS are impossible to monetize (Carpenter et al., 2009). Instead of monetary valuation and its resulting over-simplification and underestimation of total value, I advocate that the complexity of human values of wetlands be embraced. Social perception research lies in a powerful space between actual conservation behaviours and the broader motivating psychology behind them. While perceptions do not reveal everything about behaviours or motivations, they do serve as a related indicator for both factors and a potential linkage between them. For this reason, perception-based research is a necessary step towards understanding complex problems associated with human caused environmental degradation, including wetland loss on farms. In conjunction with monetary valuations, understanding perceptions can lead to management recommendations that may improve extension programs (e.g. Sherren & Verstraten, 2013). In turn, better extension programs lead to improved conservation outcomes on farms. This has influenced the methods within my project greatly. Instead of asking farmers focused and structured questions that reduce and subdivide the process of assigning values, I challenged them to talk about wetlands in the context in which they exist on the farm landscape. Farmers were asked to consider the location of the wetlands on their farms, the operational 'costs and benefits' of them and how these wetlands impact the farmers, their families and neighbours. Complexity is part of the context in which on-farm decisions are made and it is this context that I sought to investigate farmers' perceptions of wetlands.

Chapter 2 Background

Environmental problems such as wetland loss are complex problems involving a multitude of factors, both human and non-human. This section attempts to bridge traditional divides between natural sciences and social sciences, as well as qualitative and quantitative research. Its main objective is to provide background information and a review of relevant literature from the important topics that have informed the research presented here. A primer on wetlands is given, followed by a description and comparison of several EGS frameworks. Wetland valuation methods are described and finally, farmer decision-making is explored within this context.

Wetlands are landscape elements that occur throughout Nova Scotia, Canada and much of the tropical and temperate areas of the globe (Finlayson, Davidson, Spiers, & Stevenson, 1999). It is estimated that 917-1280 million ha of the earth's surface is covered by wetlands (Finlayson et al., 1999; Lehner & Döll, 2004), about 6.2-8.6% of terrestrial area. The greatest extent of global wetland resources are concentrated in the neotropics of Asia and North America (Finlayson et al., 1999). In Canada alone there are over 127 million hectares of wetland (Government of Canada, 1991), making up about 13% of the land coverage and representing about a tenth of global wetland resources.

Salt marshes and freshwater wetlands differ substantially in their form, function and threats posed to them. Salt marshes are strictly coastal habitats that are tidally affected, while freshwater wetlands do not experience any influence of salt water.

The occurrence of salt water flooding presents unique challenges for plant biota. Salt marshes are very productive ecosystems dominated by only few well-adapted species including *Spartina patens, Spartina alterniflora* and *Juncus gerardii* (Gordon Jr, Cranford, & Desplanque, 1985). Freshwater wetlands are discussed in section 2.1.

Conversion of land to agricultural use has led to extensive losses of wetland area. In the American Midwest, wetlands were an obsession for early settlers in their quest to convert them to 'productive' land (Winsor, 1987). Steam powered dredges[2] allowed for rapid land drainage (McManis, 1964), and resulted in losses of more than 80% of all wetland area in the mid-western states such as Illinois, Michigan, Indiana and Wisconsin (McCauley & Jenkins, 2005; McCorvie & Lant, 1993). In Ohio the wetland loss was even more dramatic – as much as 99% of wetlands have been converted, leaving only 31,500 ha from the original estimated 2.3 million ha (McCorvie & Lant, 1993). Many of these estimates were made using intensive remote sensing data in areas that have experienced high rates of loss of depressional wetlands such as the American Midwest (McCauley & Jenkins, 2005). However, when available, estimates can be extrapolated from historical accounts such as maps and archived material (e.g. Bromberg & Bertness, 2005; Reid, 2012, 2014; Stunden Bower, 2011; Taft & Haig, 2003).

2.1 Wetlands in Nova Scotia

A 2004 provincial inventory of wetlands revealed that about 6.6% of Nova Scotia is covered by freshwater wetlands and about 0.3% is covered by saltmarsh (NSDNR,

[2] Dredges are digging machines used to construct ditches, similar to a backhoe.

2004). These wetlands are beneficial because they provide a number of services including but not limited to: flood mitigation, water purification, water storage, recreation and others (Crumpton et al., 2005; DeLaney, 1995; Ducks Unlimited Canada, 2014; Herath, 2004; Schindler et al., 2014; Vymazal, 2007). Although they are not equally distributed, wetland resources are widespread throughout Nova Scotia, including all 8 'ecoregions' (Webb & Marshall, 1999). The Maritime Lowlands ecoregion contains contain some of the largest wetlands in Nova Scotia including the Tantramar Marsh. In the Southwest Nova Scotia Uplands ecoregion, wetlands are more sporadic because of the discontinuous rocklands (Webb & Marshall, 1999). Wetland distribution is largely due to the topography and geology of individual ecozones but can also be a result of the drainage and infilling of wetlands. However, even in places where wetland losses have been high, they are still a conspicuous part of the landscape that draws both positive and negative attention.

Within Nova Scotia, there are three wetlands of international significance under the Ramsar Convention on Wetlands. The Chignecto National Wildlife Area contains saltmarsh areas and freshwater wetlands including sinkhole ponds, bogs and reed marshes. The wetland complex is an important staging area for geese and ducks on their seasonal migration route (The Ramsar Convention on Wetlands, 2012). Musquobodoit Harbour Provincial Park also contains saltmarsh and some freshwater wetlands. It is significant for its seagrass beds (*Zostera sp.*) and the 6,000 Canada geese (*Branta canadensis)* that stage there (The Ramsar Convention on Wetlands, 2012). The Southern Bight-Minas Basin National Wildlife Area is an estuary that attracts large numbers of waterfowl as well as over 100,000 semi-palmated plovers (*Calidris pusilla*) and up to 10,000 least sandpipers (*Calidris minutilla*) (The Ramsar Convention on Wetlands, 2012).

The loss of salt marshes in Nova Scotia has a unique history when compared with freshwater wetland loss. Between the arrival of the Acadians around 1600 and their expulsion by the British in 1749 (Kanstroom, 2007) salt marshes in Atlantic Canada were rapidly converted to agricultural use (Bleakney, 2004). New agricultural techniques, brought over from Atlantic France, used dykes to drain areas of saltmarsh to produce hay and vegetables (Butzer, 2002). This was an extremely labor-intensive activity and would have required the participation of entire villages to complete (Griffiths, 2004). However the process paid dividends by creating fertile fields that produce excellent hay crops year after year (Ross, 2002). The unique growing conditions of the marsh are created by the intersection of upland and marine sediments, which the Acadians effectively used to their advantage (Bleakney, 2004). Even after the expulsion of the Acadians, their dykeland legacy lives on. In 2000, the Agricultural Marshlands Protection Act was passed, protecting the dyke infrastructure and the marshlands themselves as valuable resources (Nova Scotia Department of Agriculture, 2007). Acadian and modern dyking efforts have together led to the loss of an estimated 65% of salt marshes on the Atlantic coast (Lynch-Stewart, 1983).

Although present-day freshwater wetland distributions are relatively well known in in Nova Scotia and elsewhere, historical coverage is not and can be difficult to discover. A recent estimate of wetland coverage on peninsular Halifax showed that 18% was likely originally wetland (Reid, 2012), but the process of urban development over the past 200 years has led to its complete loss (Reid, 2014). Without accurate estimates of historical coverage throughout the province, it is a challenge to set realistic conservation targets that address the goals of maximizing potential wetland area while still allowing prudent use (or alteration) of wetlands to provide other benefits. Nova Scotia has no province-wide historical estimates of wetland coverage and therefore rates of wetland loss have never been calculated. Losses are likely to vary widely from very high in urban zones such as the Halifax area to very low in sparsely populated and wooded areas of the province. In agricultural areas, losses are likely to be high due to land drainage in an effort to create more arable land. Kessel-Taylor (1983) estimated wetland loss for two discrete areas of the province, including one in the Bridgetown area of the Annapolis Valley where agriculture is common. An estimated 42% of wetland in that area had been lost since settlement; considerably higher than in the Musquodoboit Valley (12%) (Kessel-Taylor, 1983). The 1983 study was not intended as a systematic estimation of wetland loss, but rather as a proof of concept for the Snell (1981) estimation method. The certainty surrounding these wetland loss estimations is low, but they support other literature that suggests losses are high in agricultural areas.

To combat the rapid loss of wetlands, Nova Scotia implemented the Nova Scotia Wetland Conservation Policy. The Province of Nova Scotia requires approval for alteration of wetlands larger than $100m^{2,}$ and requires an Environmental

Assessment for wetland alterations larger than 2 ha (in Environment Act (2011) regulations, not wetland policy). The policy also requires compensation for any wetland alteration that is approved to achieve no net loss of wetland area or function. In this context, compensation means that a minimum of one hectare of wetland must be created or restored for every hectare of wetland lost due to development (Austen & Hanson, 2007). In Nova Scotia, a 2:1 compensation ratio is typically required in the form of a wetland restoration but partial credit may be issued for the creation of naturalized storm/wastewater wetlands, wetland education or funding wetland research. A minimum 1:1 ratio of restoration on the ground is always required, regardless of partial credit given.

Although salt marshes are an element of the mosaic of Nova Scotia's total wetland resources, this thesis addresses only freshwater wetlands. This is for four reasons: 1) freshwater wetlands are common in the Annapolis Valley farm landscape; 2) this research was designed to complement on-going biophysical research by the Nova Scotia Department of Natural Resources (G. Parsons, pers. comm.) that focused on freshwater wetlands; 3) the type of wetland restoration completed on farms by conservation groups such as Ducks Unlimited Canada (DUC) constructs freshwater wetlands; and, 4) freshwater wetlands on farms remain at risk of drainage or filling in an effort to create more arable land, while salt marshes are classified as Wetlands of Special Significance under the wetland policy so are very unlikely to be approved for alteration.

2.2 Freshwater Wetland Functions

Wetlands are efficient performers of agriculturally useful functions in the hydrological cycle. Wetlands are a combination of aquatic and terrestrial habitats that create a unique set of conditions where typically terrestrial processes (such as providing habitat for flowering plants) can take place as well as typically aquatic processes (such as providing spawning habitat for fish and amphibians). Farms tend to rely on these benefits more than other industries because of their vulnerability to natural weather phenomena like floods and drought. Two of the most commonly cited benefits provided by wetlands (among many) are nutrient absorption and flood prevention.

Nutrient management is an important farm practice to protect environmental quality around farms and is part of the Environmental Farm Plan program (Nova Scotia Federation of Agriculture, 2013). Environmental Farm Plans aim to manage two main nutrients; phosphorus and nitrogen. Phosphorus tends to be the limiting nutrient in freshwater ecosystems, making them particularly vulnerable to eutrophication from phosphorus loading (Bomans et al., 2005). Wetlands efficiently process excess phosphorus as well as nitrogen, particularly in wetlands that experience a fluctuation on water levels (Comín, Forès, & Menéndez, 2012). While phosphorus pollution represents a threat to local ecosystems, the magnitude of global nitrogen pollution is greater and is the focus of discussion here.

Nitrogen pollution is widespread in agricultural areas and constitutes one of the most prevalent non-point source water pollutants (Townsend & Howarth, 2010).

Excess nitrate in water sources has been linked to 'blue baby syndrome' or infant methemoglobinemia, which can cause coma and death in young children (Knobeloch, Salna, Hogan, Postle, & Anderson, 2000). Excess nitrogen from the agriculture industry has also contributed to ocean dead zones where marine life is limited by low oxygen levels which has profound consequences for marine ecosystems (Diaz & Rosenberg, 2008; Dybas, 2005). Excess nitrogen also affects freshwater environments, which impacts sensitive species such as salmonids (Kincheloe, Wedemeyer, & Koch, 1979). For reasons of human health and environmental damage, reductions in nitrogen pollution are a priority in agricultural landscapes.

Wetlands in agricultural landscapes absorb nitrogen effectively and reduce the problems associated with excess nitrogen and phosphorus. Nitrogen is limiting in marine environments. Montreuil and Merot (2006) studied the concentrations of wetlands in Atlantic agricultural France (Brittany) and monitored factors that controlled nitrogen pollution. The authors found that increased coverage of valley bottom wetlands was effective at controlling N pollution from non-point sources. Several analyses have also suggested that increased landscape-scale wetland coverage, particularly in headwater regions, is effective at controlling agricultural pollutants, namely N and P (Montreuil & Merot, 2006; Verhoeven, Arheimer, Yin, & Hefting, 2006). Key parts of the nitrogen cycle, including nitrification and denitrification, are temperature-dependent reactions and thus the nutrient removal provided by wetlands can vary by season. Occasionally wetlands with agricultural inputs of N and P do not provide a net absorption of nutrients on an annual basis (Jordan, Whigham, Hofmockel, & Pittek, 2003). This is similar to patterns seen in nutrient removal by riparian buffers (Mayer, McCutchen, Canfield, & Timothy, 2007). There is good evidence, however, that the use of both wetlands and vegetated buffers prevents large amounts of nutrient pollution when applied at a landscape level (Crumpton et al., 2005). For this reason, farmers depend on wetlands for benefits such as the assimilation of wastes in farm run-off (Gouriveau, 2009).

Another benefit of wetlands to farm operations is their ability to mitigate flood related damage. Generally, increased wetland area within a watershed leads to reduced peak flows after storm events and better overall flood protection (DeLaney, 1995). Although wetland area is of considerable importance in watershed flood prevention, the interaction between type, size and location of wetlands within the watershed are complex. In their attempt to study these interactions, Martinez-Martinez, Nejadhashemi, Woznicki, and Love (2014) found that flood control was most significantly determined by individual wetland area (bigger wetlands were more effective). Their modeling study of freshwater wetlands in Michigan also suggested that wetlands in first- and third-order streams had a modest positive effect on overall watershed output after storm events. Wetlands adjacent to lower order streams (higher in watershed, closer to headwaters) are able to absorb a greater relative proportion of stream flow, and therefore have a greater impact on local flood conditions, even though the effect on total watershed output is modest (Martinez-Martinez et al., 2014). Other modeling exercises have suggested that wetlands in the headwater regions of watersheds provide the best outcomes for flood peak attenuation (Babbar-Sebens, Barr, Tedesco, & Anderson, 2013). The majority of flood impact studies involving wetlands have been based on modeling exercises. Empirical results of watershed impacts of wetland coverage are rare, but analysis on US Geological Society data from Maine, US, gauging stations suggests a relationship between wetland coverage and standardized flood peak response (Hodgkins, 1999). The data also suggest that there may be a threshold of 5% watershed wetland coverage, below which flood peak response rapidly increases in watersheds (data from, Hodgkins, 1999).

Wetland functions have been used in a multitude of ways to benefit humans beyond flood mitigation and pollution and nutrient removal. These benefits of wetlands are by-products of healthy wetland function and are important to the agricultural industry and society in general.

2.3 Ecosystem Goods and Services

The ecosystem goods and services (EGS) concept allows for the conceptualization of the various benefits that humans accrue from functioning ecosystems, such as wetlands. Originally, the EGS framework was meant to be a unifying concept between ecology and economics that arose out of the World Conservation Strategy by the International Union for Conservation of Nature (de Groot, 1987). In attempts to provide a clear conceptualization of ecosystem services various frameworks have been developed. This section first discusses EGS as a concept, before the next section compares three different frameworks for EGS.

The concept of ecosystem goods and services leverages the human-centered exploitation of resources as motivation to conserve and maintain ecosystems, which is a relatively new approach. Historically, arguments for conservation have been justified through ethical reasoning or based on the intrinsic value of nature's organisms, populations, species and ecosystems (Turner & Daily, 2008). Although many people would agree that species 'ought' to exist and may have a 'right' to exist, the argument has not been strong enough to combat unprecedented environmental destruction and the onset of a modern mass-extinction (Barnosky et al., 2011). Since 1990 and the founding of the Society for Ecological Economics there has been a push to create improved accounting systems that includes nature on the balance sheet (Turner & Daily, 2008). The concept of ecosystem services was developed in response. It emphasizes the relationship between ecosystem functions and human well-being and attempts to account for the factors that contribute to well-being. Its originators posited that providing people with a conceptual link between ecosystems and their own well being would encourage them to make choices towards the conservation of ecosystem out of their own self interest. However, there is little evidence that shows this has been effective (Laurans et al., 2013).

2.4 EGS Frameworks

A number of frameworks have been proposed to systematically and comprehensively catalogue EGS. Due to the diverse nature of how humans benefit from ecosystems, recognizing complexity while also effectively and simply categorizing services is major a challenge. EGS frameworks variously center around functional groups, organizational groups and descriptive groups (Millennium Ecosystem Assessment, 2005). Descriptive groups are organized around the nature of resources (renewable, non-renewable etc.) (Moberg & Folke, 1999) while organizational groups focus on a species, or group of species (for instance, the benefits arising from amphibians, DeGregorio, Willson, Dorcas, & Gibbons, 2014). More recently, functional groupings that lump services together by their common functions (regulating services, provisioning services) have become the predominant method for categorizing EGS (e.g. de Groot et al., 2012; de Groot, Wilson, & Boumans, 2002; Millennium Ecosystem Assessment, 2005). Even with comprehensive frameworks including the two mentioned previously, most studies of EGS are *ad hoc* and few make use of standardized methodologies or accounting units (Boyd & Banzhaf, 2007). Studies by Costanza et al. (1997; 2014), and EGS frameworks proposed by de Groot et al. (2010; 2002) as well as the Millennium Ecosystem Assessment (2005), have heavily influenced EGS research and implementation. Each is briefly discussed here to indicate how the framework has evolved and branched and to clarify our own choice.

The estimate made by Costanza et al. (1997) was the first exercise to attempt to value global natural resources economically. They did this by mining values found in previous studies for specific biomes. The unit values (per hectare) were then multiplied by the global area of each biome to achieve a total value per biome. Although they explicitly state the goal of “setting up a framework for further analysis”, they do not organize individual EGS in any hierarchical way. The authors acknowledged limitations due to a lack of valuation studies for some biomes such as deserts and tundra, and for different amount of detail and rigor in studies of other biomes. This led to tenuous results for some biomes and lower confidence in overall value. He has revisited the study in 2014 and found an even higher total economic value of the world's resources, as predicted in the initial 1997 study.

Criticisms of the 1997 study have included the lack of confidence surrounding the estimate (Serafy, 1998) as well as double counting, suggesting that some values calculated by Costanza et al. (1997) must have already been included in gross national product (GNP) calculations, which makes the comparison not mutually exclusive and undermining its original purpose. Valuing natural resources monetarily also introduces the risk of double counting services that are captured within 'indirect values' as well as 'direct values' (exclusive of GNP calculations) (Daily, 1997), a criticism that predated Costanza's attempt to value everything (e.g. Aylward & Barbier, 1992). Daily (1997) asserts that indirect values contribute to direct values and any calculations that add the two together are double counting the embodied value of indirect functions within the direct functions.

de Groot et al. (2002) developed a different typology for the organization of EGS. Their framework was developed with four function categories; regulation, habitat, production and information. The categories were enriched by sub-categories – a list of 23 individual and distinct ecosystem services. de Groot proposed a set of valuation methods (direct market valuation, indirect market valuation [avoided cost, replacement cost, hedonic pricing etc.], contingent valuation and group valuation) in order to prioritize methods to evaluate each service. In addition to listing economic tools for use in valuation exercises the model is designed to be a clear and reliable accounting method and avoid double counting, a significant challenge in valuation. Recognizing the interdependency of services, the framework is organized into an implicit hierarchy that prioritizes the more tangible provisioning and regulating services over habitat services by showing that supporting services are contributing factors to the others. The reason for this is largely pragmatic. Because habitats are "a necessary pre-condition to the provision of all ecosystem goods and service" (de Groot et al., 2002, p. 400) they are difficult to assign values to. Habitat services are limited to the most direct of all conceivable habitat service; 'refugium functions' and 'nursery functions'. This avoids the double counting of less direct habitat services, which can be embodied in the direct provisioning and regulating services. For instance, the production of lumber in a woodlot (a provisioning service) may already embody the supporting service of soil formation within the woodlot, thereby, counting a service twice if both services types are included. As with habitat services, information services are also treated differently. de Groot et al. (2010) acknowledge the explicit contribution that nature makes to spiritual enrichment and leisure opportunities but also recognizes that these services are not easily valued economically.

A revised edition of the framework (de Groot et al., 2010) renames 'information services' as 'cultural and amenity' services, but contain a similar set of sub-categories. Habitat services are also referred to as supporting services, drawing a similarity to the Millennium Ecosystem Assessment Framework for Ecosystem Goods and Services (2005), which is discussed below. In addition to the categorization of EGS, the authors also present a framework (adapted from Haines-Young & Potschin, 2010) that links ecosystems and biodiversity to human wellbeing through services such as flood protection, nutrient removal etc. (Figure 1). Such conceptual links had been proposed by previous studies, namely, Turner and Daily (2008).

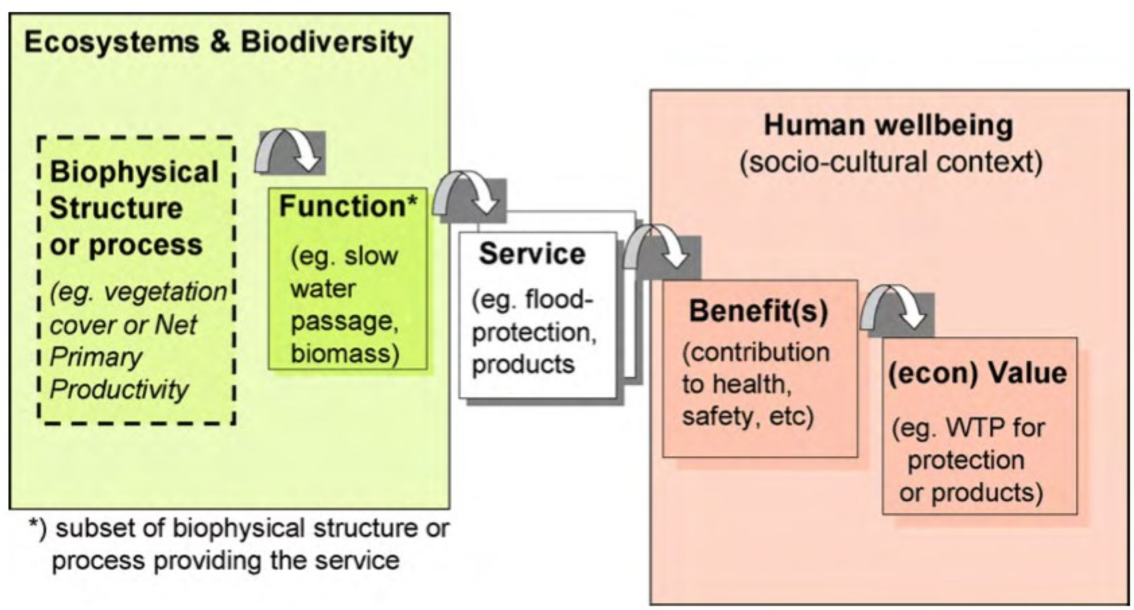

Figure 1 Conceptual link between functioning ecosystems and ecosystem services. (de Groot et al., 2010, adapted from Haines-Young & Potschin, 2010).

The framework conceived by de Groot et al. is used by many studies in the EGS literature including recent, relevant examples of agricultural EGS (Brooks, Smith, Holland, Poppy, & Eigenbrod, 2014). Beyond academic literature this framework is used by The Economics of Ecosystems and Biodiversity (TEEB) initiative. The group is hosted by the United Nations Environment Program (UNEP) and advocates accounting for the values of EGS to governments around the world (The Economics of Ecosystems and Biodiversity, 2014).

The Millennium Ecosystem Assessment (MA) (2005) was created to assess the large-scale effect that humans have on the environment. To draw a fundamental link between humans and our life-sustaining ecosystems, the Framework for Ecosystem Goods and Services was developed under the MA. It is similar to the framework developed by de Groot *et al.* in that it has an organizing structure of four service categories and 29 services types (Figure 2, not all service type are listed).

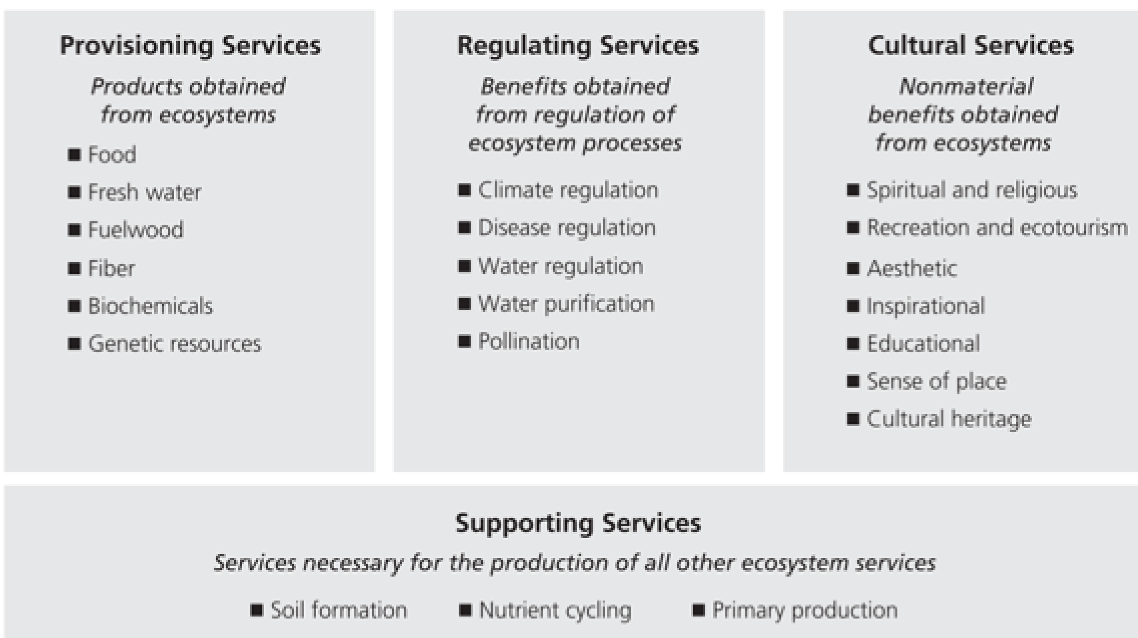

Figure 2 Ecosystem Goods and Services Framework (Millennium Ecosystem Assessment, 2005)

Supporting services in the MA EGS are similar to 'habitat' services within the de Groot *et al.* framework however the latter limits habitat services to nursery habitat and gene pool protection whereas the MA framework includes soil formation, nutrient cycling and primary production. A conspicuous difference between the MA and de Groot frameworks is the care taken to avoid double counting. The de Groot (2010) framework limits the number of 'supporting' services , recognizing that their values are likely embodied within the values of more direct services such as provisioning services. On the other hand, the MA framework is much more conceptual, and not designed to be an economic tool for valuation. The MA framework provides a conceptual link between supporting services - which are seldom noticed by humans - and more tangible cultural, provisioning and regulating services. While the framework does not provide a clear process of valuation, it has a conceptual traction that has made it the most widely used and acknowledged framework in existence (Smith & Sullivan, 2014). Table 1 reveals some of the intricacies that are unique to each framework. While the MEA (2005) framework and de Groot et al. (2002) framework share much of the same structure, the language used by Costanza et al. (1997) and de Groot et al. (2002) are most similar.

Each EGS framework is ultimately an abstraction of ecosystem function because the complexity and interconnectedness of ecosystems defies simple categorization. Compartmentalization of ecosystem services is an anthropocentric activity that simplifies overall ecosystem function and ascribes intentionality to these services that are merely a by-product of the evolution of ecosystems. Ecosystems were clearly not designed to provide fresh water, or control the climate to the benefit of humans. However, these are the most easily recognized beneficial effects of ecosystems. Categorizing these outcomes is a useful activity, however, that allows humans to appreciate ecosystem values and may provide motivation not to undermine mechanisms that allow for the flow of such beneficial effects.

Table 1 Table showing EGS categories and corresponding grouping from three EGS frameworks.

Costanza et al. (1997)	Millennium Ecosystem Assessment (2005)	de Groot et al. (2002)
Recreation	Recreation and Ecotourism	Recreation and tourism
Cultural	Cultural Heritage Values	Spiritual and historic information
	Spiritual and Religious Values	
	Cultural Diversity	
	Aesthetic Values	Aesthetic information
	Inspiration	Cultural and artistic inspiration
	Educational Values	Science and education
	Knowledge Systems	
	Sense of Place	
	Social Relations	
Water Supply	Fresh Water	Water Supply
Genetic Resources	Genetic Resources	Genetic resources
	Ornamental Resources	Ornamental Resources
	Food and Fibre	Food
Raw Materials		Raw materials
	Biochemical medicines	Medicinal Resources
	Fuel	
Refugia	Habitat Provision (not included as part of MA framework, but included as a provisioning service within this thesis)	Refugium
		Nursery Function
Gas regulation	Air Quality Maintenance	Gas regulation
Biological Control	Biological Control	Biological control
Climate Regulation	Climate Regulation	Climate regulation
Erosion Control and Sediment Retention	Erosion Control	Soil retention
Pollination	Pollination	Pollination
	Regulation of Human Disease	
Waste Treatment	Water Purification and Waste Treatment	Waste treatment
Water Regulation	Water Regulation	Water regulation
Disturbance Regulation	Storm Protection	Disturbance regulation
Nutrient Cycling	Nutrient Cycling	
Soil Formation	Soil Formation	
	Primary Production	

Legend

Uncategorized	Cultural/Informa-tion Services	Provisioning Services	Regulating Services	Supporting/Habit at Service

The discrete categorization of ecosystem function into ecosystem services is a common characteristic of the above-mentioned EGS frameworks. This allows each of them to be used in tandem with valuation efforts. However, all the frameworks are not exclusively designed for one type of valuation; both monetary and non-monetary valuation techniques can and should be used (Norton & Noonan, 2007; Schröter et al., 2014). EGS valuation categories and techniques are discussed in section 2.4 along with their criticisms.

2.4 Wetland Valuation

In 1981, Canada adopted the Ramsar Convention on Wetlands (Matthews, 1993), agreeing to the promotion and wise-use of wetland resources through the implementation of a wetland conservation policy. This was a sea change from earlier times where wetlands were actively eliminated and considered a useless scourge on the landscape (Dodd, 1999; Giblett, 1996). Parties to the Ramsar agreement implicitly acknowledge that wetlands are valuable, in part due to the EGS they provide, however, it is challenging to convey wetland value in order to justify conservation. Various valuation methods have been proposed and utilized for this purpose, borrowing from disciplines such as economics, ethnography, and the natural sciences. This section discusses monetary and non-monetary valuation concepts and methods.

2.4.1 Monetary valuation

As complex ecosystems, wetlands function in many ways, positively contributing to the conditions that facilitate human life on earth. Through the lens of ecosystem services, we can see that these functions are beneficial to humans. Compared to their area, wetlands provide a large amount of ecosystem services (Zedler & Kercher, 2005) and communicating the value of these services is one of the biggest challenges in wetland conservation. The spectrum of economic valuation studies includes research focusing on everything from single wetlands (DeGregorio et al., 2014) to the global contribution of all ecosystems on earth (Costanza et al., 1997; Costanza et al., 2014; de Groot et al., 2012), however most studies lie somewhere between the extremes, valuing one service in a series of wetlands (Woodward & Wui, 2001).

All told, the estimated value of wetlands in NS is $7.9 billion annually (Wilson, 2000). Because of their relatively small area within agricultural landscapes, and the incredible amount of EGS they provide, they are a perfect example of how the EGS framework can provide a compelling argument for conservation. Van Vuuren and Roy (1993) estimate that intact wetlands in Canada provide EGS valued at $8,800 per hectare annually whereas intensive agriculture produces about $3,700/ha/year showing the value of maintaining intact wetland habitats. A comprehensive study of all of New Jersey's EGS by Costanza et al. (2006) showed that wetlands were the most valuable ecosystem in the state. Freshwater wetlands were providing $9.4

billion annually in ecosystem services primarily through disturbance regulation (flood abatement etc.) and water filtration (Costanza et al., 2006).

Wetlands are the second most economically valuable biome on Earth after coral reefs (Costanza et al., 2014), thus, wetlands contribute a considerable amount of ecological goods and services, through recreation opportunities, flood protection, water filtration *etc*. Although wetlands are widely considered valuable, there remains considerable variability between studies (several orders of magnitude) (Woodward & Wui, 2001). About half of the studies included in a meta-analysis of wetland EGS showed that wetlands have a service value of less than $100/ha/year, however the most valuable 10% of studies suggested values above $200/ha/year with some values as high as $10,000/ha/year (Woodward & Wui, 2001) (Figure 3). No significant relationship was observed between the date each study was conducted and the calculated value.

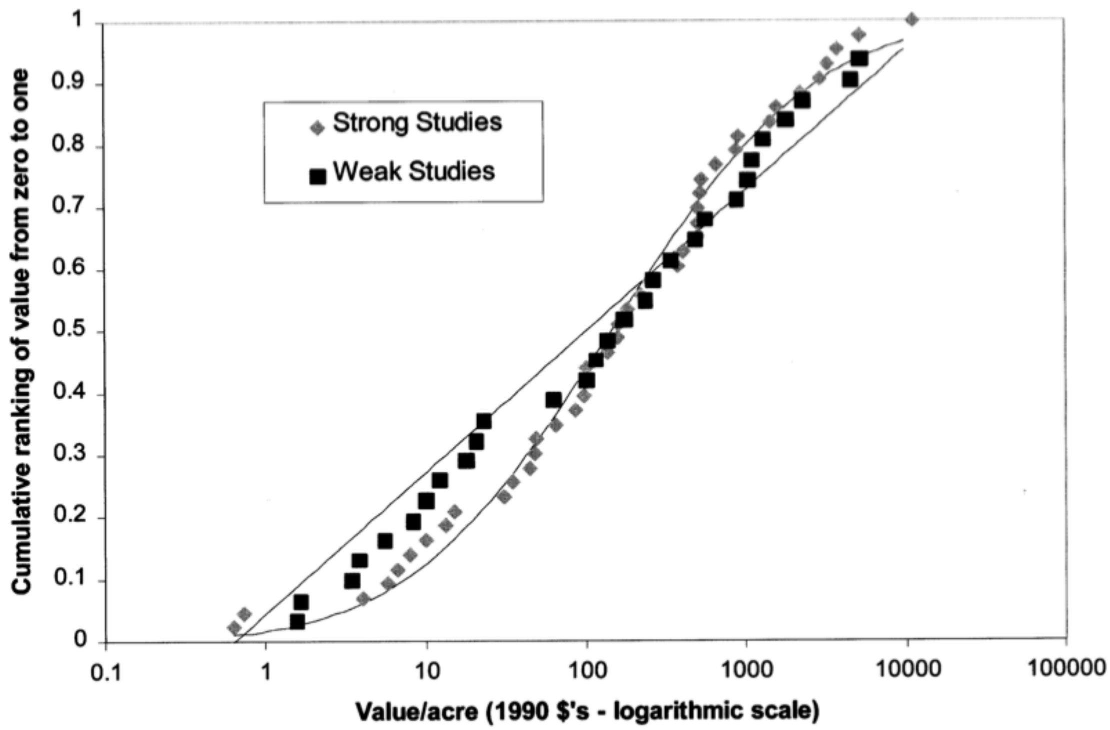

Figure 3 Cumulative distributions of wetland values broken down by study quality (Woodward & Wui, 2001). Strong studies included more reliable data, robust econometrics and statistical certainty. Weak studies lacked one or more of these features.

Wetland valuation studies are driven by different research questions and can differ in the services measured and the number of services measured. Interestingly, the number of services measured by any given study did not have an effect on the valuation outcome, *i.e.* studies that measured more services did not find greater total wetland service value (Woodward & Wui, 2001). While some wetland studies attempt to be comprehensive in their assessment, single-service studies tend to be the most common. These 'single' services included groundwater recharge, water quality control, habitat for aquatic species, flood control and others (Woodward & Wui, 2001).

The TEEB valuation database provides over 1300 estimates of ecosystem service values from across the world (S. Van der Ploeg & de Groot, 2010). Estimates of EGS from inland wetlands in North America and Europe are presented in Table 2. The estimates show a wide range in values with a median value of $305/ha/year (2014, CAD). Valuation estimates are different between services, which is no surprise; what is interesting is how much they differ between valuation efforts within a single service. Consider the values for water purification from floodplains; in Europe, one study estimated the value of this service at just over $100/ha/year while another study in Germany (within Europe) estimated the value at over $16,000/ha/year, a 160-fold increase. Wetland function does vary widely, from year to year and also within years. This variation has been shown in studies of biophysical function such as Jordan et al. (2003). There is also a large amount of variation between economic valuation studies that use different valuation techniques. However this does not seem to produce a systematic bias in results (Figure 4) (Woodward & Wui, 2001). Wetland values can also change based on their 'scarcity' and proximity to populations. Wetlands in urban or semi-urban areas are exposed to more human traffic which makes them more valuable, particularly as recreation sites (Mitsch & Gosselink, 2000a). This could account for some difference found between similar service valuations in different locations.

Table 2 Inland wetland ecosystem service values by valuation method and wetland type. Data from TEEB valuation database and limited to North American and European wetlands. All values expressed in 2014 Canadian Dollars.

Ecosystem Service	Value (2014 CAD/ha/year)	Wetland Type	Geographic Area	Valuation Method
Attractive landscapes	108	Swamps / marshes	United States of America	Hedonic Pricing
Biodiversity protection	305	Swamps / marshes	Canada	Benefit Transfer
Carbon sequestration	5	Peat wetlands	Canada	Benefit Transfer
Deposition of nutrients	434	Floodplains	Europe	Benefit Transfer
Drainage	11 042	Swamps / marshes	United States of America	Replacement Cost
Ecotourism	207	Floodplains	Europe	Benefit Transfer
Waste treatment [unspecified]	5 577	Floodplains	United States of America	Contingent Valuation
Water purification	411	Swamps / marshes	Canada	Benefit Transfer
	102	Floodplains	Europe	Benefit Transfer
	16 538	Floodplains	Germany	Avoided Cost
Flood prevention	1074	Peat wetlands	Canada	Benefit Transfer
Provisioning values [unspecified]	125	Floodplains	Europe	Benefit Transfer
Total Economic Value	60 042	Wetlands [unspecified]	Europe	Benefit Transfer
	6 423	Swamps / marshes	Europe	Benefit Transfer
	332	Peat wetlands	Europe	Benefit Transfer
	766	Floodplains	Europe	Total Economic Value

Studies that attempt to determine economic values of wetlands use a multitude of economic valuation techniques (Table 2). Direct or market valuation is often not possible for wetlands because so many of their benefits are not captured or traded in typical markets. Indirect valuation is therefore necessary. Most types of valuation result in only an assigned value because people do not actually pay for the environmental services. One common method is called 'contingent valuation', which includes willingness-to-pay studies. In such studies, people are asked how much they would be willing to pay for a marginal increases in quantities of environmental goods or services (outside the market) (Hanemann, 1994). The opposite of this is 'willingness to accept' which determines the minimum economic value one would be willing to accept in order to forego the same environmental good or services. Interestingly, these seemingly equal and inverse values do not always align (Hanemann, 1991). Other monetary valuation techniques include replacement costs, travel costs, and hedonic pricing to name a few. Byström (2000) used replacement cost of wetland nitrogen removal to assign a value to wetlands in agricultural Sweden. The otherwise-free services provided by wetlands amounted to 213 million Swedish Kroners ($32.7 million CAD) (Byström, 2000). The production of deer within a Michigan agricultural landscape was valued using travel costs; the aggregate amount of money that hunters spent hunting deer in the area. It was estimated that if the deer population fell, it would result in a reduction of $15 million USD total economic activity because fewer hunters would be traveling to the resource. Hedonic pricing also reflects a willingness to pay through the tracking of surrogate markets such as real estate or other directly valued goods. Bin (2005) showed a positive association between proximity to wetlands and the value of homes in Portland, Oregon. The multitude of tools used to assign values to wetlands show a similar variation among studies but contingent valuation studies often value wetland services the most (Figure 4).

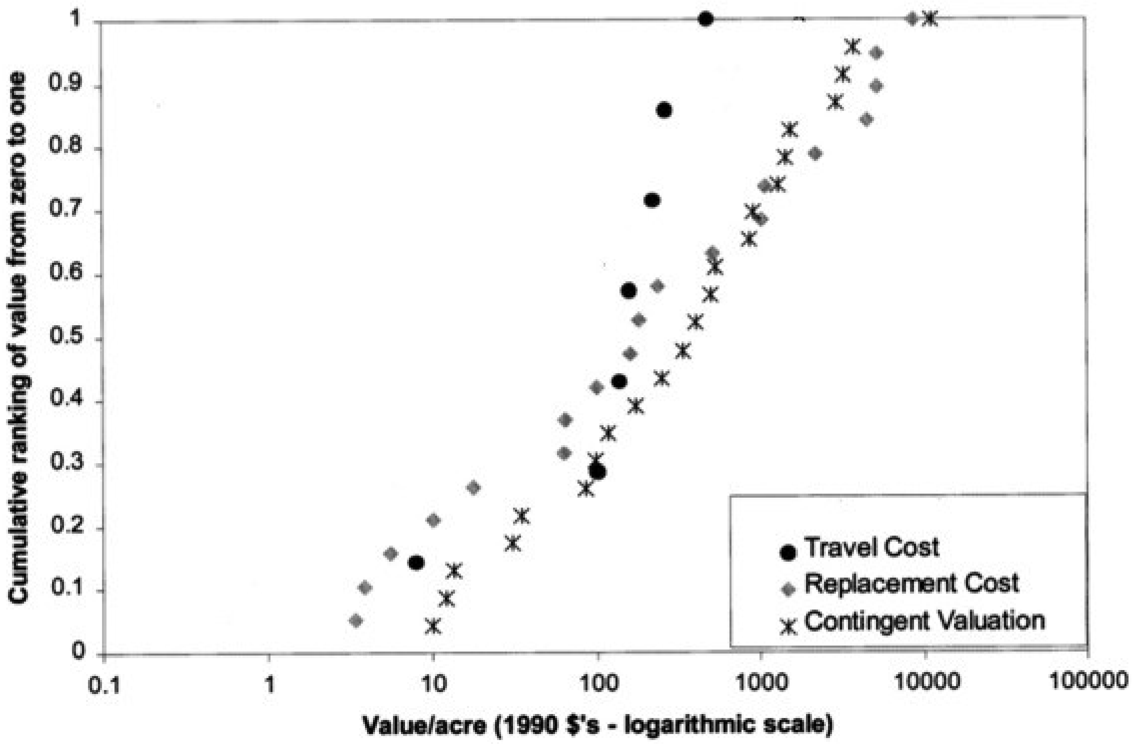

Figure 4 Cumulative distributions of wetland values broken down by valuation method. Adapted from Woodward & Wui (2001)

Economic valuation exercises have produced estimates that show that removal of wetlands is against the best interest of society. While, the economic value of wetlands shows that wetlands are well-worth maintaining in most cases, their effectiveness at actually motivating conservation, particularly in the policy realm is lacking (Laurans et al., 2013). Examining the EGS framework from an economic perspective has merit, but a comprehensive justification for wetland conservation is not captured by economics alone.

2.4.1.1 Criticism of Monetary Valuation

Although economic valuation of wetland EGS is the most common valuation (monetary and otherwise) technique by a wide margin, it is not without its criticisms. An early example of economic valuation of wetlands by Pope and Gosselink (1973) used an estimation of the cash value of tidal wetlands to justify the construction of less destructive bridges rather than roads in the creation of a new highway. In this case, avoidance of wetland destruction would have increased the overall cost of the highway project. The article was closely scrutinized and criticized as being an incomplete marriage between economics and ecology, two concepts that were deemed incompatible by Shabman and Batie (1978). As with the earliest uses of economic valuation, more recent attempts to value ecosystems have faced the same criticisms, which remain largely unresolved. Costanza et al. (2014) defend the use of economic valuation and dismiss concerns about the ultimate uses of economic valuation - such as the treatment of ecosystems as private commodities- as 'misconceptions'. Schröter et al. (2014) provide a strong synthesis of the criticisms against monetary valuation including the anthropocentrism of the EGS concept, potential conflicts between EGS maximization and biodiversity maximization and the deficiencies of economic valuation among others.

The EGS framework is better equipped to handle certain EGS categories than others. Cultural (Millennium Ecosystem Assessment, 2005) or Information services (de Groot et al., 2002) are sometimes ignored because they are not easily valued using monetary techniques (Carpenter et al., 2009). These service types are not only less tangible (for example 'cultural diversity') but are also partially embodied in the monetary values of other services including biodiversity services (Schröter et al., 2014). Interestingly, cultural services (e.g. aesthetic beauty, recreation opportunities) are more conspicuous to people's day-to-day lives than other service categories (Brown, Montag, & Lyon, 2012). This information can be revealed through social science methods such as participatory EGS mapping (Brown et al., 2012) showing that valuation studies are complemented by non-monetary methods (discussed in section 2.4.2). In the case of wetlands, the most economically valuable services have been calculated as, roughly in order: landscape water regulation, water purification, waste treatment, flood prevention, sequestration of nutrients, biodiversity protection, ecotourism and attractive landscapes (Table 2). Only two of these were cultural in nature.

2.4.1.2 Monetary Valuation in Canada

In Canada, economic valuation is more commonly used as a justification for conservation rather than direct payment for services or the purchase and sale of wetland ecosystems. For instance, Ducks Unlimited Canada and the Boreal Songbird Initiative co-sponsored a report on Manitoba's boreal forest values. In addition to the $117 billion in potential carbon credits stored in the boreal forest, they established that boreal wetlands provide an estimated $39 billion annually in water filtration (Anielski, Wilson, Development, & Initiative, 2005). Ducks Unlimited and the Boreal Songbird Initiative do not advocate for the sale of wetlands or even a payment for service. Rather, they illustrate the economic value of boreal wetlands as evidence for their perpetual conservation. However the economic valuation of these resources is only symbolic in furthering conservation efforts because little economic benefit can be realized, only avoided costs.

Payment for ecosystem services (PES) allows groups that actively or passively facilitate the production of ecosystem services to be compensated for their efforts or for avoiding degrading activities. Although they are just beginning, programs exist in Canada to facilitate the payment for EGS created through beneficial management of agricultural lands. Programs called Alternative Land-Use Services (ALUS) provide payment to farmers engaging in beneficial management practices in Canada. Currently there are active programs in Alberta, Ontario and Prince Edward Island (PEI). Land-use practices such as vegetative buffers, exclusionary fencing and retirement of marginal (high slope) land are compensated financially. This allows farmers to be paid in exchange for the ecosystem services maintained by engaging in beneficial management practices (Campbell, 2014). In PEI, annual payments range from \$185 ha^{-1} for expanded buffer zones and retirement of high slope land to \$250 ha^{-1} for placing land under conservation easements (Government of Prince Edward Island, 2007). While these services are not directly related to wetlands, wetland enhancement is common to all Canadian ALUS programs (Campbell, 2014).

2.4.2 Nonmonetary Wetland Valuation

While economic valuation is nothing new and wetlands have one of the longest histories of economic valuation, there are still significant gaps in the use of the EGS concept to promote conservation. Schröter et al. (2014) make it clear that economic valuation is not the only way forward with the EGS concept, a realization of earlier ecological economists such as Norton and Noonan (2007). The valuation of wetlands through means other than economic terms could effectively complement past valuation efforts and fill in the gaps left by economic valuation. While wetlands have a substantial history of monetary valuation through the EGS framework, what is missing is the equivalent social research. EGS frameworks represent a 'boundary concept' that is flexible enough to be used by different disciplines – even those often at odds with each other – but with enough immutable characteristics to maintain identity across disciplines (Abson et al., 2014; Star & Griesemer, 1989). The potential for research into EGS from many different disciplines including those in the life sciences and the social sciences fosters interdisciplinarity (Abson et al., 2014). Interdisciplinarity can positively contribute to solving complex problems such as the depletion of natural resources (Gunn, 1992).

The anthropocentric nature of the EGS framework allows for its use in studies of social perceptions. Based on personal experience, humans construct rich understandings of the landscapes that surround them (Adams-Webber & Kelly, 1979). Studies into human perceptions – the way people think about landscapes - provides an alternate valuation system that is complementary to, but outside, economics. Some ecological economists that have advocated against the monistic economic treatment of EGS in valuation literature recognize that social studies (and ecological ones) are an important part of the pluralism needed to address environmental problems (Norton & Noonan, 2007).

Studies that focus on the economic aspects of EGS valuation dominate the literature and expose the lack of literature originating in the social sciences. Interpreting the EGS framework solely in economic terms has dominated EGS research, yet it has not motivated the necessary conservation measures to ensure the sustainability of ecosystem-derived services (Norton & Noonan, 2007). In the same way, a strict reliance on ethical and moral arguments has not been successful to inspire the wise-use of natural resources (Turner & Daily, 2008). Measuring and accounting for perceptions, along with economic and ethical arguments may prove to be a useful system of checks and balances that can inform weaknesses in the other methods and point to better conservation strategies. Consider a hypothetical example, a willingness-to-pay valuation study may show that a woodland near your home is worth $400/ha/year for services rendered in the form of 'recreation and tourism'. The municipality that owns the forest spends an order of magnitude more on maintenance each year than the forest is 'worth'. This could lead to a sale of the forest for timber or other use. Consider a social perception study of the same forest. Participants in the study may love and cherish the forest as a public resource but be unwilling to pay for its use because it has always been free of cost[3]. This could be historically or culturally engrained in social perceptions but it would be unlikely to

[3] A Finnish study conducted a similar experiment that showed about 16% of respondents rejected payments in principle (Harris, 2010), showing that the outcome to this thought experiment is not unfounded.

be discovered through monetary means. In this case it is clear that the forest is worth considerably more than the initial estimate of $400 dollars $ha^{-1}year^{-1}$, however this is not captured through willingness-to-pay, which is characteristically used to gauge worth in economic valuations.

Although the above example is purely hypothetical, it is interesting to note that social assessments of EGS values have provided results that are substantively different than economic valuations. The importance of multiple valuation methods lies in capturing a more complete set of values (beyond monetary values), which better reflect the human relationship with ecosystems and better justify their conservation. Qualitative methods of determining perceptions of ecosystems are discussed in the following section (4.3).

Studies have employed many methods to understand social perceptions. One of these is establishing responses to landscape images provided by researchers. Sheppard (2005) argues for instance that visualizations of climate change scenarios should be used to catalyze action towards solutions (mitigation and adaptation) to climate change by bringing perceptions of landscapes into the forefront of actors' minds. Other studies have argued that imagery, particularly environmental imagery, actually influences perceptions, and can be a communication tool that can engages participants to contemplate climate change scenarios (O'Neill, Boykoff, Niemeyer, & Day, 2013; Petheram, Stacey, Campbell, & High, 2012). More structured approaches, such as having participants sort photos representing different ecosystem services (image-based Q method), can help understand how these are perceived by citizens and other stakeholders (Milcu, Sherren, Hanspach, Abson, & Fischer, 2014).

Sometimes the research subjects themselves capture the imagery in such perception research. For instance, photo-elicitation has been used to elicit perceptions in the agricultural context, including the identification of wetlands as priority landscape features in Nova Scotia (Sherren & Verstraten, 2013). In Australia, Sherren, Fischer, and Fazey (2012) showed that the perceptions held by 'holistic [pasture] managers' in the Lachlan River catchment were different than those of 'non-holistic managers'. Using photo-elicitation, researchers identified that holistic managers perceived biodiversity and pasture heterogeneity as more beneficial than non-holistic pasture managers. These perceptions could prove to be a leverage point for extension officials to encourage holistic management in an effort to restore scattered tree cover (and the EGS it provides) to the SE Australian landscape (Sherren et al., 2012).

EGS can also be used as a framework to map valued places in a landscape. Unlike a valuation exercise (economic or otherwise), Brown et al. (2012) used participatory mapping (Public Participatory Geographical Information Systems, PPIS) to determine spatial distributions of ecosystem services in Grand County, Colorado (among many examples of this methodology). Among the top ten most commonly mapped EGS, five were cultural services, suggesting that they were not only conspicuous services but also valued by participants. A review of PPGIS showed that, while methods are not yet standardized, most studies targeted cultural (and provisioning) ecosystem services (Brown & Fagerholm, in press). This is contrary to economic valuation, which often does a poor job at assigning a monetary value to cultural services (Carpenter et al., 2009).

Survey methods are also widely used to gather social perceptions. Contingent valuation studies often employ surveys that determine stakeholders willingness-to-pay (Heal, 2000), however surveys of social perceptions do not assign monetary values, opting instead for assessments of relative importance or other social metric. While surveys are cost-effective at reaching many people they lack the depth of interviews (Bryman, 2012), making it difficult to capture the underlying values. They are also difficult to structure to force choices, and when the survey has high face validity (i.e. it is clear what is being tested, and what is the 'right' answer), such values can be inflated. For instance, Smith and Sullivan (2014) found that farmers reported that nearly all EGS were of high importance (>8/10). Other surveys, particularly those with larger sample sizes, have been able to discover ecosystem service bundles; services that are often associated with each other (Martín-López et al., 2012). Rather than identifying a monetary value of ecosystem services, Martín-López et al. (2012) identified three bundles: 1) an 'urban group' including cultural services, air purification and micro-climate regulation; 2) a 'multi-functional group' with cattle and forest product provisioning, soil formation and hunting services; and, 3) a 'rural group' which includes food provisioning services. Martín-López et al. (2012) also provide an excellent summary table of social perception studies and the methodologies used (Table 3). This table shows how few studies (12) use social perceptions of EGS in comparison with the 1310 economic valuations from which the previous table draws.

Table 3 Studies of social perceptions of ecosystem services with methodology and ecosystem types. Excerpted from Martín-López et al. (2012)

Source	Type of ecosystems (after [71])	Category of ecosystem services (after [71])	Study area	Methodology	Stakeholders sampled
Martín-López, 2007 [72]	Wetlands	Provisioning; Regulating; Cultural	Doñana Protected Area, Spain	Face-to-face questionnaires	Local people, visitors, environmental experts
Rönnbäck, 2007 [49]	Coastal system (mangroves)	Provisioning; Regulating; Cultural	Gazi and Makongeni, Kenia	Semi-structured interviews	Local people
Agbenyega, 2008 [30]	Forests	Supporting; Provisioning; Regulating; Cultural	Eastern England, UK	Questionnaires	Local people
Iftekhar, 2008 [32]	Wetlands	Supporting; Provisioning; Regulating; Cultural	Nijhum Dwip, Bangladesh	Individual interviews and group meetings	Local people and key informants
Sodhi, 2009 [33]	Forests	Provisioning; Regulating; Cultural	Forested parks in Myanmar, Philippines, and Thailand	Individual interviews	Local people
Hartter, 2010 [31]	Forests and wetlands	Provisioning; Regulating	The Kibale National Park, Uganda	Semi-structured interviews	Local people
Zheng, 2010 [34]	Drylands	Provisioning; Regulating; Cultural	Mongolia Plateau	Individual interviews and face-to-face questionnaires	Local people
Castro, 2011 [73]	Drylands	Provisioning; Regulating; Cultural	Almería, Spain	Face-to-face questionnaires	Local people, visitors, environmental experts
Lamarque, 2011 [26]	Grasslands of mountains	Provisioning; Regulating; Cultural	French Alps, Austrian Alps, and English uplands	Individual and group interviews	Regional experts and local farmers
Vilardy, 2011 [74]	Coastal wetland	Provisioning; Regulating; Cultural	Ciénaga Grande of Santa Marta, Colombia	Semi-structured interviews and expert meetings	Local people and environmental experts
Warren-Rhodes, 2011 [50]	Coastal system (mangroves)	Provisioning; Regulating; Cultural	Solomon Islands	Semi-structured interviews	Local people
Calvet-Mir, 2012 [27]	Home gardens	Provisioning; Regulating; Cultural	Catalan Pyrenees, Spain	Semi-structured interviews and questionnaires	Local people, visitors, and scientists

Ecosystem services are an implicit driver for many agri-environmental programs. The end goal of such programs is the restoration of functioning ecosystems so they may continue to bestow benefits on human populations. However, farm EGS are not a major focus of social perception studies. An exception to this is Smith and Sullivan (2014) who used surveys as well as interviews to elicit farmer perceptions of various EGS. They found that farmers consider most EGS to be of crucial importance, each with a mean of 8 or higher (out of 10). As mentioned previously, results of social studies on the 'value' of EGS are substantively different than those using monetary valuation techniques. Smith and Sullivan found that the sample group of farmers considered a wide variety of EGS to be nearly equally important. Variability was greater among farmers' perceptions of the manageability and vulnerability of each EGS. This is contrasted by the high variability between monetary values of individual EGS within individual studies (Costanza et al., 2014; Costanza et al., 2006; Liu, Costanza, Troy, D'Aagostino, & Mates, 2010). Whereas Smith and Sullivan (2014) show a barely discernable difference in perceived importance between the EGS, de Groot et al. (2012) report values that differ by at least an order of magnitude in every biome type.

Few studies have addressed the disparity between social perceptions and monetary values, although some have examined it qualitatively (e.g. Vanclay, 2004; Vanclay & Lawrence, 1994). Even fewer studies address the topic using agriculturally relevant EGS. A wetland-specific study of perceptions of Southeast Asian farmers and fishers show results consistent with Smith and Sullivan. Brooks et al. (2014) use a normalized value derived from social perceptions (from focus groups) to show how they differ from monetary values of EGS. Farmers and fishers assigned similar values to most wetland EGS, while monetary values varied greatly. Brooks et al. (2014) show that while one service can overshadow others in economic terms, stakeholder perceptions of EGS value are spread amongst a wide variety of EGS (water supply, flood control, fisheries etc.) (Smith & Sullivan, 2014). Differences between economic values and socially-perceived values may provide a leverage point that could be exploited to encourage conservation on farms.

Farmers are managers for 403,000 hectares (7.6%) of land in Nova Scotia (Statistics Canada, 2012), which have the potential to produce significant EGS. Farmers are also beneficiaries of EGS, including those from wetlands. Beneficiaries are not explicitly incorporated into the de Groot et al. (2002) or the Millennium Ecosystem Assessment (2005) EGS frameworks, even though they are key stakeholders as both land managers and EGS beneficiaries. Theoretically farmers can potentially benefit from on-farm EGS, resulting from both their own land management practices and those of their neighbours. Farmers can also be put at a disadvantage by their or their neighbours' poor environmental practices. Zhang, Ricketts, Kremen, Carney, and Swinton (2007) acknowledge that farm management practices partially determine how farms are influenced by ecosystem services and disservices, bring farmers into the EGS framework as actors. The concept that farmers may be able to manipulate EGS and improve ecosystem condition is implied in many agricultural extension programs (Environmental Farm Plan Program, Agricultural Biodiversity Conversation Plans), but the perceptions and choices of those farmers are rarely investigated and are only recently being acknowledged in the EGS literature (e.g. Reyers et al., 2013). Rounsevell, Dawson, and Harrison (2010) built upon the EGS concept by adding explicit acknowledgement of ecosystem service beneficiaries (ESB's). The authors acknowledge that ESB's may be very different from one another and these characteristics place different demands on EGS. Additionally ESB characteristics may affect the way ecosystem services are perceived and influence how beneficiaries make decisions about implementing practice meant to bolster on-farm EGS production.

2.5 Farmer Adoption

Along with their economic and ecological impacts, farming is a significant cultural activity that is rooted in history (Vanclay, 2004), evidenced by the development of unique farming styles in different cultures (Van der Ploeg, 1994; Vanclay & Enticott, 2011; Vanclay, Howden, Mesiti, & Glyde, 2006). Farmers are also responsible for the management of more land than any other group on the planet (Tilman, Cassman, Matson, Naylor, & Polasky, 2002). Farmers must finely balance ecology and economics all within the confines of an established cultural environment.

There is a body of on-going research into social factors associated with the environment, from recycling behaviour, to the development of agricultural cultures. McKenzie-Mohr (2013) explains that while education alone is not enough to change behaviours, investigating the perceptions of the 'barriers and benefits' of sustainable behaviour is crucial to inform its promotion. The author uses commonplace examples such as recycling programs and his own personal commute to work to show that social science methods (focus groups, surveys) are effective in examining the barriers and benefits that are "internal to the individual" (McKenzie-Mohr, 2013, p. 9).

Perceptions are inherently 'internal to the individual' and also key to understanding the motivations of sustainable behaviour. The agricultural equivalents to 'sustainable behaviours' are the beneficial management practices (BMPs) advocated by academics and governments alike. Normally the responsibility of extension agents, the promotion of BMPs is not always as effective as desired (Pannell et al., 2006). While some BMPs have been adopted widely it seems that adoption rates depend on “characteristics of the learning process, the potential adopters or the conservation practices” (Pannell et al., 2006). While most studies have assumed farmers to be ‘rational’ profit maximizers, there is evidence against this. For instance, even though some on-farm water quality management techniques were deemed profitable by the US Dept. of Agriculture (USDA), not all farmers engaged in the activities (Cooper & Keim, 1996). The reason behind this was assumed to be economic in nature: farmers were ‘risk averse’ (Cooper & Keim, 1996). However, adoption rates among farmers have been associated with social factors such as how many neighbours and community members had also adopted the technology (Bandiera & Rasul, 2006) and the farmers’ ‘attachment to place’ (Marshall, 2009). Nova Scotian farmers who participated in the Environmental Farm Plan Program reportedly did so to improve relations with non-farming neighbours and to publicize farm stewardship practices (Atari et al., 2009).

How extension information is spread also has an impact on its efficacy. Commonly in Nova Scotia, farmers get information about conservation practices through interpersonal relationships and government agencies, but other sources are used widely as well (Atari et al., 2009). Information learned from neighbours has a longer lasting effect than information from extension agents (Krishnan & Patnam, 2014). While the adoption process is not completely understood and likely changes from location to location, what is clear is that extension programs cannot ignore the impacts that social factors have on adoption rates (Vanclay, 2004). Finally, it may be worth noting also that the reasons for farmers adopting a BMP may not be the 'right' one, according to extension officers (i.e. not to promote EGS), as Sherren and Verstraten (2013) noted of wetland construction in Nova Scotia.

2.6 Conclusion

Investigation of socially derived values of EGS is a worthwhile practice because economic values alone have not been able to motivate the necessary conservation to maintain EGS. While economic valuations of wetlands and the services they provide have been useful justifications for conservation, they have not resulted in reduced environmental degradation on a wide scale. Wetlands are a vital part of agricultural landscapes, with a true value not currently captured in accounting systems used by farmers or in monetary EGS valuations. Social perceptions of EGS can be used to ameliorate the system of EGS promotion on farms and encourage increased conservation through improved extension programs. Investigating the value of ecosystems using EGS is an inherently anthropocentric exercise, and has so far been dominated by economic valuation studies. Important steps are being taken to improve notions of the value of ecosystems but thus far there has been little work undertaken in Nova Scotia. The research in this thesis attempts to characterize farmer perceptions of agriculturally relevant EGS derived from wetlands to inform resource managers on how to better encourage effective and efficient wetland conservation behaviour among farming communities.

Chapter 3 Methods

Measuring farmers' perceptions of natural phenomena - in this case perceptions of wetland ecosystem goods and services - is a particular challenge because it calls for qualitative methods that lack clear methodologies. Furthermore, where protocols do exist, they are not always applicable, causing *ad hoc* methods to be developed that make comparisons difficult. This chapter describes the method of interview data collection used as well as a novel method of analysis that utilizes numerical calculations - unlike many qualitative studies (Malterud, 2001) - to add in clarity, rigour and transparency. Stratification between wetland types was used to identify which EGS are associated most commonly with each.

3.1 Wetland Stratification

Wetlands vary widely in their appearance, function and cultural significance. From oligotrophic bogs to forested Cyprus swamps, the moniker of 'wetland' is applied to a huge range of landscapes. Even in Nova Scotia there is a considerable diversity of wetland types, which have different characteristics and functions. For instance, freshwater wetlands are some of the most biodiverse ecosystems found in North America (Flinn, Lechowicz, & Waterway, 2008), while salt marshes have very low biodiversity (Gordon et al., 1985), largely attributable to high nutrient levels and frequent saltwater inundation (Pollock, Naiman, & Hanley, 1998). Human affinity for wetlands also varies by wetland type. The value of housing has been tied to proximity of certain types of wetlands, showing that houses close to open water wetlands are more valuable (Bin, 2005). To acknowledge the diversity in both wetland function and human perceptions toward different wetland types, a simplified categorization protocol was developed.

Wetlands were categorized into wetland types through the assessment of visual characteristics. Each wetland type was characterized by three attributes; the presence of open-water, types of vegetation and relative water depth. Rigorous wetland classifications (e.g. Cowardin, Carter, Golet, & LaRoe, 1979; Warner & Rubec, 1997) use more factors including soil and vegetation characteristics and topography, providing a level of detail beyond what was required for this study. Simple classification based on visual characteristics was justified because visual characteristics play a large part in the formation of landscape preferences (Frank, Fürst, Koschke, Witt, & Makeschin, 2013; Zheng, Zhang, & Chen, 2011). Wetlands in this study were categorized into one of three mutually exclusive categories; covered marshes, open marshes or farm ponds. While the following wetland categories are meant to encompass some common wetlands found in the Annapolis Valley, they were not intended to represent the full range of wetland types present in the Annapolis Valley or across Nova Scotia. The term 'marsh' is borrowed from more formal classification systems such as Cowardin *et al.* (1979) and the Canadian Wetland Classification System (1997) but are not intended to connote precise definitions. Here, 'marsh' is used to describe two types of wetlands that are fed primarily by surface waters. All sample wetlands were located in the Annapolis Valley with the majority found in the northwest area of the valley (Figure 5).

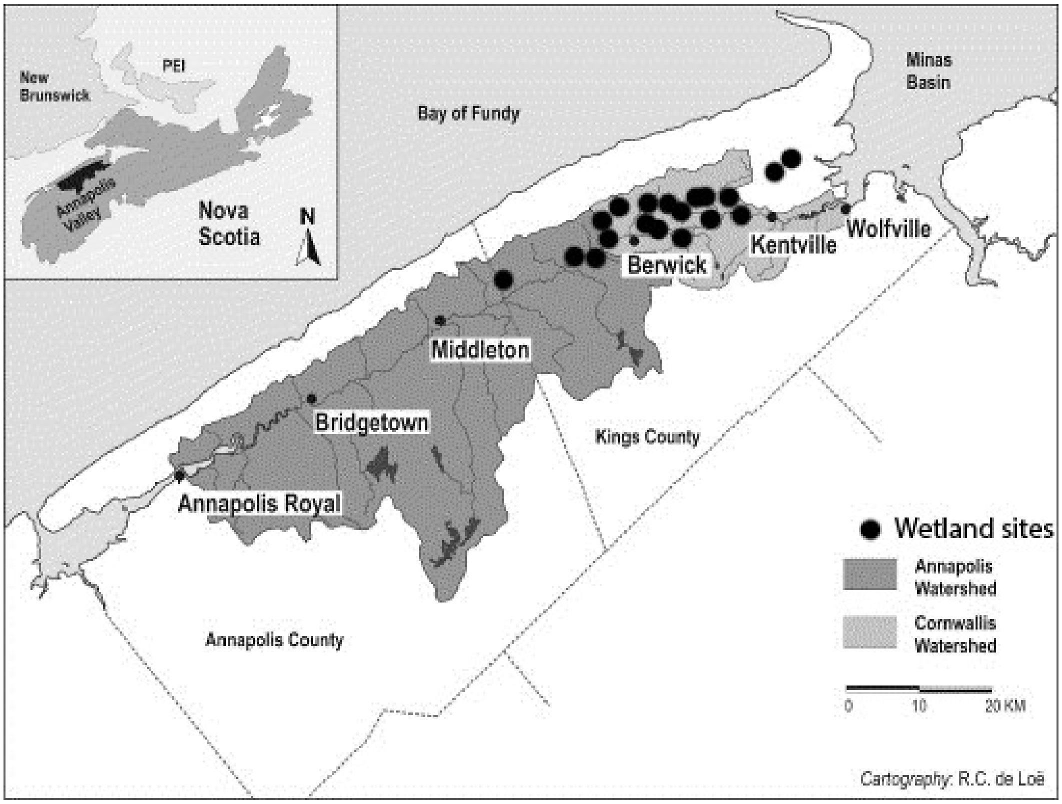

Figure 5 Annapolis Valley NS, featuring approximate wetland locations. Map adapted from Timmer, de Loe & Kreutwiser (2007).

3.1.1 Covered Marshes

Covered marshes (Figure 6) had no open water and were densely vegetated. Species including *Typha sp., Carex lacustris, Impatiens capensis, Prunus viginiana* and *Polygonum sagittatum* dominated in covered marshes, as did several grass species such as *Phalaris arundinacea*. Covered marshes represented several types of wetlands under formal wetland classification systems (e.g. Cowardin et al., 1979; Warner & Rubec, 1997) including scrub-shrub swamps and wet meadows. The majority (6) of the wetlands would have been considered wet meadows, dominated by non-woody species. All (8) were associated with a small brook. Although measurements such as soil types, depth to water table, and nutrients were not taken, these wetlands all had water at or near the surface but lacked any significant open water areas. Covered marshes were the least disturbed sites within the sample because they were already low-lying and marginal lands for agriculture. Constructed or restored covered marshes may not regain the characteristic tussock surface topography for the better part of a century after construction (Zedler & Kercher, 2005). The covered marshes in this study were occasionally disturbed sites, due to a history of cultivation, but all were natural in origin.

Figure 6 Covered marsh type wetland with dense sedge community.

3.1.2 Open Marshes

Open marshes had significant surface water and also featured emergent vegetation, floating or submerged macrophytes and a 'naturalized' riparian zone (Figure 6).

They were typically natural in origin although the history of wetland alteration and creation was unknown for many wetland sites. Ecologically, open marshes were more mature than recently created ponds and typically included species such as *Typha sp.* and *Carex spp.* near the water's edge, and *Solidago sp., Rosa virginiana* and *Salix bebbiana* around the margins of the wetlands.

Figure 7 Open marsh covered with emergent vegetation, *Typha sp*.

3.1.3 Farm Ponds

Farm ponds (Figure 7) were not natural in origin and were exclusively built for specific purposes such as providing water for irrigation and fire protection, but also provided recreational activities like ice-skating. These ponds were a particular research interest because they are common in the Annapolis Valley agricultural landscape. Furthermore, there was on-going research into their biophysical characteristics including their suitability as supporting habitat for ducks and geese (Banks, 2013; Millet & Bondrup-Nielsen, 2013). Farm ponds had little to no emergent vegetation and few floating or submerged macrophytes. They were the most manicured of all the sites and vegetation was often mowed to the edge of the water.

Figure 8 Farm pond surrounded by *Phalaris arundinacea*.

3.2 Landscape Level Wetland Identification

Finding suitable wetland sites is a necessary step toward measuring the social perceptions of the farmers who own them. Wetlands included in this study were required to be on active farms and fall into one of the above three predetermined wetland categories. While it is not possible to accurately determine wetland type from aerial photography, it is possible to identify farms and wetlands more generally. The appearance of surface water and topography features were used to identify preliminary wetland types that were further ground-truthed during site visits. There are 848 farms within the approximately 1000 km^2 study area (Daft Logic, 2014; Nova Scotia, 2011a, 2011b). Free online access is available to aerial photography and satellite imagery of acceptable quality from Google Inc. Visual scans of the Annapolis Valley area of such maps were used to identify wetland complexes where wetland density is higher than the surrounding area. These areas were then thoroughly searched for individual wetlands that could be used as suitable sampling areas. The provincial wetland inventory (Nova Scotia Department of Natural Resources, 2004) was used to help identify wetland types that are not easily discernable from aerial photographs such as open and covered marshes. With the use of the provincial wetland inventory, sites were targeted to achieve relatively even numbers of interviews around the three types of wetlands: farm ponds, open marshes and covered marshes.

A previous study (Greenland-Smith, 2011, and subsequent unpublished research), as well as field visits, showed that farm ponds were likely going to be the easiest to find and not likely to limit the study size. As such, marsh type wetlands were targeted preferentially with the assumption that farm ponds were present at most farms.

3.3 Participant Recruitment

Once potential wetlands were identified, longitude and latitude were recorded and cross-referenced on a map showing the Property Identification Numbers (PID) (Province of Nova Scotia, 2014). The PID's could then be used to acquire names and addresses for landowners. This step posed an unexpected challenge in that some land parcels were owned under company names or had incomplete information associated with the title owner. In the case of land parcels owned by businesses, similar means were used, but it was not always possible to reach a representative from the business, as was the case for numbered companies. However, most farm businesses had sufficient contact information for managers or land-owners who were eligible for participation in the study. When full name and address information was available for the owner of the personally owned land, on-line phone books were used to acquire contact phone numbers. After the contact information was generated, phone calls were placed to eligible farmers. These 'cold calls' entailed a request to speak with the owner or one of the owners listed in the PID information. This was followed with a brief introduction to the study, including the time commitment involved and the purpose of the research. Responses from potential participants were overwhelmingly positive and almost all farmers who were called agreed to take part in the study. There were several occasions where the owners of the land had retired and passed on the land, usually but not always to younger family members. In these cases the contacted farmers provided further contact information for the current managers of the land. Response rates are discussed in the following chapter. Farmers who participated were not compensated in any way and generously volunteered their time towards the research presented here.

Demographic information on farmers was collected through the use of a voluntary and farmer-reported demographic information collection sheet (Appendix IV). Demographic information was used to assess significant sources of bias, which is discussed in section 4.3.3. In-depth information such as length of farm ownership was not formally collected. Individual attributes of farmers could likely do influence their perceptions of wetlands, however the study presented here is meant to provided a characterization of perceptions among farmer rather than the drivers of such perceptions. Alternative methods including surveys that allow for the construction of a logit model with predictive power would be more appropriate for inquiry into the drivers of perceptions.

3.4 Interviews

Interviews are a distinctly qualitative data collection method and can lead to rich data sets (Bryman, 2012). The qualitative nature of interviews allows for the collection of values and attitudes that are otherwise difficult to capture quantitatively (Raykov & Marcoulides, 2010). The challenge in designing an interview is limiting interviewer bias. Some have argued that the key to controlling interviewer bias is to ask each question in the exact same way each time, limiting the variability in interpretation (Gorden, 1986). More commonly, interviewers strive to standardize the *meaning* of their question while allowing some deviation in phrasing (Barriball & While, 1994). An extension of this interviewing style is unstructured interviewing, where the prompts themselves are allowed to vary between interviews while the meaning of the interview as a whole is standardized (Bryman, 2012). Interviews, including unstructured interviews, allow researchers to glean more information than surveys due to the limited opportunities for response in the latter (Kvale & Brinkmann, 2009). For instance Likert-scale surveys often have as few as 5 options for respondents to choose from, whereas interviewees can speak until their point is made.

Authentic perceptions of environments require active engagement of participants with the sensory experiences of the real world. Perceptions of natural environment can be deeply held values, and such values are often not accessible through conventional means such as surveys (Kamakura & Mazzon, 1991). Respondents to surveys engage in a passive recollection of natural conditions, which can lead to inaccuracies (Owen, Duinker, & Beckley, 2009). Alternatively, when participants are actively engaged with the landscape a deeper understanding of the human response to nature can be gleaned (Mausner, 2005). In keeping with this, researchers have advocated for research that takes place within the study environment (e.g. Mausner, 2005; Owen et al., 2009). Such *in situ* research is helping explore farmers perceptions by adding context and allowing the natural surroundings to aid in interviewing processes (Riley, 2010).

We used unstructured interviews, which took the form of conversations with open-ended and flexible question prompts (Zhang & Wildemuth, 2009). Unstructured interviews rely on the spontaneous generation of questions, however it is important to plan them meticulously and always keep in mind the desired direction of the interviews (Patton, 2005). Each interview was conducted and audio-recorded, *in situ* with farmers in close proximity to the study wetlands, which were used as visual stimuli for conversation. Interviewees were free to guide the interviewer to different areas of the wetland and point out interesting features such as nesting areas for birds and farm irrigation infrastructure. The interview style was similar to 'go-along' interviews which may be guided by the interviewees and provide an intimate and flexible way to engage with the land (Carpiano, 2009; Evans & Jones, 2011). Using natural landscape features, such as wetlands, as prompts allowed us to reduce researcher bias in the questions posed of each interviewee. Instead of fixed questions in a fixed order, farmers were free to speak about whatever they thought was important about the wetland in question, allowing for reliable farmer accounts of important issues (Riley, 2010). Using flexible go-along interviews alters the power balance between interviewer and interviewee, empowering the interviewee and encouraging free discussion of topics (Evans & Jones, 2011).

Each interview began by prompting the farmer to "tell me about this wetland". In several cases this was enough to spark nearly an hour of conversation between the researcher and participant however, other prompts were used to encourage conversation. However, interview prompts were few and designed not to sway the topics of conversation, allowing the farmers to guide interviews and speak to the issues that were most important to them. For instance, prompts were not specific to ecosystem services (see Appendix I for complete list). Prompts were delivered if conversation slowed or if respondents required encouragement to elaborate on topics of conversation (Kvale & Brinkmann, 2009). In order to maintain flow of thought, participants were not interrupted while speaking. Interviews were approximately 30 minutes in duration but some lasted 50 minutes while others were as short as 15 minutes. The variance in interview duration was mainly attributable to how much farmers were willing to talk, which is a challenge in unstructured interviews (Bryman, 2012). Some farmers were happy to engage in detailed conversations, whereas other farmers were more reserved and did not stray far from the questions asked.

Participants were made aware that the purpose of the interviews was to gain insight into their perceptions of wetlands in the agricultural landscape. For the most part, participant farmers were willing and indeed pleased to talk about wetlands and ponds. However, certain participants were also very keen to discuss other topics that were only tangentially related to the research topic. In this case, the discussion was allowed to run its course. Conversation was then redirected back towards the topic of wetlands using one of the predetermined prompts (Appendix I). It was crucial that side topics and tangential conversations were allowed because of the theoretical underpinning that assumes conversation topics that are discussed often and at length are more important to those who discuss them. If the researcher actively diverts conversation constantly towards the target topic the importance of these issues would be falsely magnified and not be an honest reflection of the participant's perceptions. Practically, this has its drawbacks; namely the time it takes during the interview and transcribing phase. Unstructured interviews were challenging because occasionally participants expected more structured questions. Every participant was informed that the interview would seem more like a conversation that a series of questions but this was uncomfortable for some participants and led to shorter interviews with less detailed information.

When farmers mentioned topics that required more detailed prompts for detail they were recorded and added to a roster of prompts used in future interviews. For example, coyotes were mentioned by many farmers but not always with sufficient detail. After prompting the first farmer who mentioned coyotes with "are the coyotes good or bad and do they take livestock?" each subsequent farmer who mentioned coyotes was prompted in the same way. Thus, the list of interview prompts was added to throughout the sampling period as farmers acknowledged more topics that required further inquiry. However, individual prompts remained consistent between farmers. The process allows farmers to control the direction of each interview and discuss the topics that are most important to them while still maintaining the credibility and dependability of consistent questioning, two key factors in the trustworthiness of research findings (Lincoln, 1985). Prompts were only used if the farmer mentioned the corresponding topic of conversation *i.e.* unnecessary prompts were not used to avoid the introduction of bias.

Studies of social perceptions that use a single interview with participants are limited because they are unable to monitor seasonal changes in environmental perceptions. It is reasonable to assume that farmers perceptions of wetland-derived EGS would change throughout the season because there are seasonal changes in wetland function and the resultant EGS. For instance, water regulation is closely tied with seasonal precipitation patterns. In the spring, wetlands fill with water and slowly release this throughout the fall (Acreman & Holden, 2013). This critical gap was addressed through the use of paired interviews, where each farmer was interviewed in May and again in September. Every farmer in the sample was contacted and asked to participate in a second interview; however, some farmers had scheduling conflicts that could not be overcome or other personal reasons for not participating. The attrition rate between the two field visits was 5 out of 19. Interviews were conducted in a similar manner, however the prompts were seasonally appropriate and focused more on the changes between seasons rather than the basal conditions of each wetland (see Appendix I).

As with all outdoor interviews, weather is a dynamic factor that can affect interview success. Interviews were scheduled a day or two before the interviews as they were largely weather dependent. Farmers are much more available during and shortly after rainfalls because the fields are not workable until they are dry. On several occasions, farmers requested to be interviewed only if it *was* raining so as to make the most of their time. For the most part, farmers are also habituated to outdoor work and rain does not discourage them from going outdoors. Interviews were conducted in batches of up to three per day, however scheduling conflicts required that some interviews be done on days when no other participants were available.

3.5 Data Management and Analysis

All interviews were transcribed *verbatim* from audio recordings during the month after each interviewing period. Background noise was removed to aid in the transcription process. All conversation, regardless of topic, was transcribed to provide an accurate length of interview for comparison with individual ecosystem goods and services. Transcriptions were completed in a denaturalized style whereby there was no attempt made to capture the mumblings or body language that usually accompanies verbal communication within the written transcripts (Mero-Jaffe, 2011). Limiting the transcripts to a denaturalized style expedited the process of transcription. May interviews were transcribed in batches in June and September interviews were transcribed in October.

To reduce the influence of the researcher's voice, questions and prompts were paraphrased in the transcripts and not included in the coding process. For the most part, questions by the researcher would have comprised less than one percent of the interview transcripts, but minimizing this influence was important to the objective of attaining reliable proportions of interview content for each EGS.

Coder reliability was dealt with in two ways. An *a priori* structured codebook based on the MA (2005) EGS framework (see below) limited the interpretation demanded from the code and a single coder was used. Inter-coder reliability is sometimes warranted when study goal dictate the standardization of coding procedures between coders. Using a single coder has both benefits and drawbacks. The drawback being that the research audience has little means to assess the coder's judgment, while the benefit is that every interview is coded in the same way with a high degree of reliability (Stevens, Lyles, & Berke, 2014). It must be acknowledged however, that a different coder might have done the job differently.

Transcripts were analyzed for content related to EGS as outlined in the Millennium Ecosystem Assessment (MA) (2005). Coding was completed using Nvivo 10 (QSR International Pty Ltd., 1999– 2014) qualitative data management software, a common qualitative data management software. Codes were generated using the Millennium Ecosystem Assessment Framework for Ecosystem Goods and Services and organized in the same way, whereby there were four broad EGS categories and many sub-categories. Coding was completed at the level of the sub-categories and applied to the parent codes, for example if a particular passage dealt with skating on a pond it would be coded at "recreation and tourism" (the sub-category node) and automatically coded at the parent node "cultural services". Codes were assigned at the sentence level to give an approximate standardization to the length of each coded section. This allows for the number of codes to be a better representation of the overall proportion of content assigned any given code. This, however, was not used for the calculations of average coded content and ended up being inconsequential to the final results.

To aid in the interpretation of interview data, each sentence was also assigned 'contextual' codes, which did not relate to the MA EGS framework. These codes included whether the content was elicited by the wetland or another stimulus and whether the content was 'positive' or 'negative'. Including only EGS that were elicited by the wetland itself gives a more reliable approximation of farmers' perceptions and avoids confusion with other factors such as weather and field conditions. These factors were coded as 'non-wetland stimuli' and not included in final calculations for wetland-related EGS. Additionally, each sentence discussing an EGS category was interpreted as either 'positive'; indicating the presence of an ecosystem service, or 'negative'; indicating the absence of a service or the presence of a disservice. This provided context beyond the presence or absence of each EGS and allowed for seasonal differences to arise in their interpretation. For instance, biological control services of wetlands may be perceived negatively during spring when insects are breeding, but positively during the fall when insects are not as numerous. Each instance of an EGS-related discussion was also coded either as 'positive', the presence of a service or 'negative', disservices or the absence of a service.

3.6 Quantification

Numerical expression of qualitative data has both clear benefits and drawbacks. Number-based quantities are intuitive and share a language between analyses, studies and disciplines. However, in the social sciences, numerical expression typically results in a loss of richness, which is touted as one of the primary benefits of qualitative interview data (Bryman, 2012). Qualitative data has been associated with richness at the expense of rigour while the opposite is true for quantitative data (Guba & Lincoln, 1994). Because of the complementary strengths and weaknesses associated with qualitative and quantitative methodological approaches there is considerable effort put forth to develop hybrid approaches. There is no standardized protocol for manipulating social data, which has led to a perceived lack of rigor[4] (e.g. Sandelowski, 2001; Williams & Patterson, 2007).

We used a novel method of expressing qualitative data (particularly interview-based data) using quantitative (albeit relative) metrics. Numerical expression of qualitative data has been used to effectively and efficiently present data from complex analyses (Williams and Patterson, etc.). The methods presented here are designed to build on these while bringing transparency and common sense to numerical expression. While some qualitative researchers decry the use of numbers in qualitative research (Maxwell, 2010; Sandelowski, 2001; Sherren & Verstraten, 2013), numerical outputs are built into most qualitative data management programs and are in all likelihood being used by most studies, even those that do not express data in numerical terms.

To identify the topics that are most important to farmers we based our method on the assumption that farmers will speak more about topics they consider important than unimportant. These assumptions are based on the highly structured nature of conversation and its ultimate purpose; to serve as an exchange of information that reveals perceptions held by the speaker (Eggins & Slade, 1997). Similar assumptions are made for other qualitative analyses such as discourse analysis (Wodak & Meyer, 2009). Previous studies have used metrics such as 'column inches', the amount

[4] While the concept of quantitative rigor has not been appropriately applied to qualitative data, there are researchers who have suggested qualitatively appropriate ways to determine rigor in research. See Tyrväinen & Väänänen (1998)

newspaper columns published on a given topic in inches to quantify the emphasis on certain media topics over other and expose bias in the media (Herman & Chomsky, 2008). Another, more complex analysis examined the number of times that narratives, such as 'beauty' or 'biodiversity' were associated with landscape elements such as sparse trees and deadfall (Sherren et al., 2012).

We used two metrics to determine which topics were most important; the number of farmers who mentioned a given topic in their interview (n_f) and the average character content, as a percentage of discussion about a given topic ($\bar{x}$). Number of farmers was calculated to give a relative metric of how widely acknowledged a given topic was among the participating farmers. Average content was calculated in an effort to determine the relative importance between any two topics or ecosystem services. Within the calculation for average content there is controlling factors for both the number of times each farmer was interviewed and the fact that some farmers are more verbose than others. These decisions were predicated on the assumption that every farmer's voice is equally valuable. The percentage of coded transcript character content (x_{fi}) of each interview (i) completed with a farmer (f) was summed and divided by the number of interviews (n_i) conducted with that farmer to provide an average coded content for each farmer. These averages were then summed and divided by the number of farmers (n_f) to produce a weighted average. Only farmers that discussed the topic in question ($x_{fi} > 0$) were included in the calculated averages. The calculation can be expressed as:

$$\bar{x} = \frac{1}{n_f} \sum_{f=1}^{n_f} \left(\frac{1}{n_i} \sum_{x_{fi}>0}^{n_i} x_{fi} \right)$$

The two-dimensional metrics provide numerical representation of how widely recognized each topic was within the sample (n_f) but also how important those topics were to the group of farmers that discussed them ($\bar{x}$). Only topics discussed in relation to wetlands were included in the calculations for either metric. The method of numeration provided results that could be interpreted with greater depth than a single metric, such as the average content amongst the entire group of farmers.

One limitation of the calculation is that there are no accompanying statistics that can assess significant differences between factors or suggest a level beyond which results are considered significant. To make up for this lack of significance testing, an arbitrary limit was created based on a natural division between the top ~10% of possible results[5]. These results were defined by a combination of the two available metrics. Appreciable results must have a substantial average content (≥3%) and over 1/3 of the possible farmers reporting that service. To avoid confusion with the concept of statistical significance, all results beyond the threshold were described as consequential or substantial. Numerical and qualitative results are presented in the next chapter in the form of a manuscript designed for submission to an academic journal.

[5] Top 10% results based on the 264 possible results presented in Table 5 in the following chapter. 19 out of 264 (7.2%) were deemed substantial results.

Chapter 4 Farmer Perspectives on Ecosystem Services: Are All Wetlands Perceived as Equal?

This chapter was written with the intention of publishing in a peer-reviewed journal, with my committee as co-authors. As such, there is some repetition from previous chapters in the introduction and methodology sections. As the primary author I use "*we*" throughout to acknowledge the coauthors of the paper.

4.1 Abstract

The ecosystem goods and services model is implicit in many conservation schemes, including agricultural extension programs with the aim of conserving wetlands. The design of such programs requires an understanding of how farmers perceive wetlands and the cost and benefits they bestow. Very little research has sought to do this. Employing unstructured interviews with 19 farmers and using three types of wetlands on their Nova Scotia farms as *in situ* visual prompts, we determine which wetland-related services are recognized by and most important to farmers. We see that not all wetlands are valued equally and that farmers consider 'farm pond' wetlands the most valuable in EGS terms. We also see seasonal variation in farmer perceptions and recommend multiple-visit elicitation accordingly to establish robust understanding. We discuss the implications of this study for effectively integrating extant EGS frameworks with agricultural extension programs and discuss possibilities for improved wetland conservation in the agricultural landscape.

4.2 Introduction

Some engineering of the landscape is necessary to make it more suitable for agriculture. Although the change can be drastic, particularly in very intensive agriculture, the landscape is rarely completely altered and the resulting production areas still reflect some characteristics of the pre-existing ecosystem. In fact, agriculture relies on the remnant functions of that ecosystem for many beneficial services such as water provision, pollination of crops by wild insects and the availability of soil resources (Abson et al., 2014; Matson, 1997; McGrath, 2014; W. Zhang et al., 2007). In the academic literature, these services are sometimes described as ecosystem goods and services (EGS).

Wetlands provide more EGS per unit area than any other ecosystem besides coral reefs. Freshwater wetlands occupy only about 0.3% of the earth yet they produce about 20.5% of all EGS in terms of monetary value (Costanza et al., 2014), making them the second most valuable biome on the planet by absolute value (Costanza et al., 2014; de Groot et al., 2012). It has been estimated that coastal and freshwater wetlands in Nova Scotia produce CDN$7.9 billion of value per year in the form of ecosystem goods and services (Wilson, 2000). The high level of EGS production by wetlands reflects their critical ecological importance and difficulty of replacement, making wetlands a priority conservation target (Keddy et al., 2009; Matthews, 1993).

With respect to EGS supply, not all wetlands are created equal. For example, peatlands provide important carbon storage services (Belyea & Malmer, 2004; Bridgham, Megonigal, Keller, Bliss, & Trettin, 2006) but have only limited EGS value with respect to nutrient removal (Vymazal, 2007). In farmed landscapes where wetlands are often heavily managed, it may be impossible to maximize benefits such as nitrogen and phosphorus removal while also maintaining high levels of species diversity or other EGS within the wetland (Hansson, Brönmark, Anders Nilsson, & Åbjörnsson, 2005; Zedler, 2000). Maximizing the EGS outputs of wetlands is also complicated by the fact that they vary seasonally (Jordan et al., 2003).

Despite the services they provide, wetlands are often in conflict with agriculture because they generally occupy areas of low-lying, flat topography. Commonly subject to conversion for agricultural practices, low-lying wetlands have been lost at rates as high as 80-90% in both Canada and the United States, especially in prairie regions (Dahl & Allord, 1996; Keddy et al., 2009; McCorvie & Lant, 1993; Stunden Bower, 2011) and parts of the Great Lakes region such as southwestern Ontario (Walters & Shrubsole, 2005). However, in the agricultural context, wetlands are particularly useful because the water regulation services provided by wetlands absorb excess water to prevent flooding and store it for supply during droughts (Brander, Brouwer, & Wagtendonk, 2013; Mitsch & Gosselink, 2000b). They also have the ability to remove phosphorous and nitrogen, which are common contaminants in agricultural run-off (Hansson et al., 2005).

Since the 1950's there has been a remarkable shift in attitude and policy regarding wetlands, from wetlands considered a 'toxic miasma' or wasteland that should be eliminated at all costs, to wetlands valued as providers of "the conditions and processes that sustain human life" (Giblett, 1996; Salzman, Thompson Jr, & Daily, 2001, p. 310). However, not all wetland stakeholders have experienced the attitude shift to the same extent. The agriculture industry has been slow in adopting the change, possibly because of direct conflicts between maintaining wetlands in the farm landscape and ensuring sufficient arable land. Standard accounting systems also ignore the value of functioning ecosystems and obfuscate the benefits of maintaining wetlands (Jenkins, Murray, Kramer, & Faulkner, 2010; Wilson, 2000).

Only recently has payment for ecosystem services (PES) been implemented in Canada, with the Alternative Land User Services (ALUS) program (Campbell, 2014).

The broader shift in wetland understanding occurred coincidently with early uses of the EGS model (Costanza et al., 1997) and the Framework for Ecosystem Goods and Services (Millennium Ecosystem Assessment, 2005), the dominant framework for analyzing EGS (Smith & Sullivan, 2014). The framework divides services into four semi-hierarchical groups; provisioning, regulating, cultural and supporting services that provide the basis for the first three (see **Error! Reference source not found.**). Since 2005, the EGS model has been modified to suit agricultural applications with notable developments made by incorporating disservices and recognizing the EGS beneficiaries as key actors in their delivery (Rounsevell et al., 2010; Zhang et al., 2007).

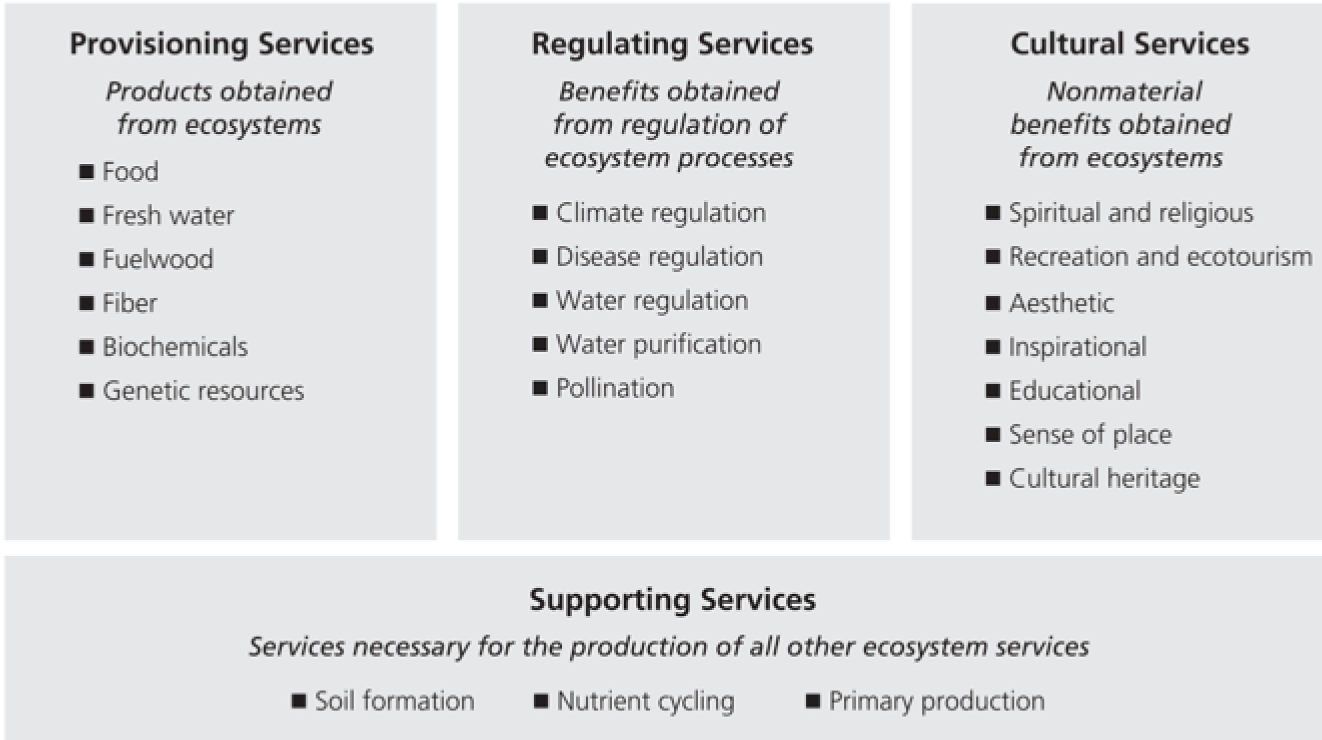

Figure 9 Ecosystem goods and services framework (MA, 2005).

Farmers are important stewards of EGS in terms of the area of land they manage, as well as the freedom they have around their management practices. Scholars are thus increasingly seeking to understand how farmers perceive and influence EGS (Smith & Sullivan, 2014). The methods used are often ethnographic, involving the elicitation of *held* values over the investigation of *monetary* values, as Norton and Noonan (2007) advocate. This is consistent with some early literature outlining human values which states that values held by humans are more useful than the market-assigned values of objects (Rokeach, 1973). Exploration of farmer-held values surrounding EGS improves the understanding of farmer experiential knowledge, which complements well-established conventional science (quantification, valuation) and should lead to a more comprehensive understanding of agricultural wetland conservation (Fazey, Fazey, Salisbury, Lindenmayer, & Dovers, 2006). Initial research on the topic suggested that perceptions are contextual and can vary by ecosystem characteristics and farmers' primary motivations (Smith & Sullivan, 2014).

We draw on this background and attempt to address the critical gaps in research on farmer-held values through our study, which looks specifically at farmer perceptions of three types of wetlands in their production landscapes, Our study area, the Annapolis Valley of Nova Scotia, Canada, has experienced high historical wetland loss, which the Nova Scotia Wetland Conversation Policy was designed to address by increasing restrictions on wetland alteration. As a result, farmers and their organizing bodies in Nova Scotia were concerned about the approval of the N.S. Wetland Conservation Policy (Nova Scotia Department of the Environment, 2011), which commits the province to 'no-net loss of wetlands' among other goals. Concerns were mostly related to how the policy might affect farmer's ability to manage lands. However, many NS farmers also appreciate the value of wetlands in the farmed landscape and are actively involved in wetland restoration and creation, often in collaboration with Ducks Unlimited Canada (Sherren & Verstraten, 2013).

Through *in situ* farmer interviews, we test the impacts of season and wetland type on the EGS that farmers perceive wetlands to be delivering. We use the EGS Framework from the Millennium Ecosystem Assessment (2005) for our deductive analysis, and briefly examine how these may differ from monetary valuations. This research helps to reveal motivations for wetlands currently being conserved, restored or created as well as suggesting potential policy leverage points which may be valuable for outreach efforts directed at conserving wetlands in farmed landscapes.

4.3 Methods

In May 2013, we used three types of wetlands as *in situ* visual prompts during unstructured interviews with 19 farmers. Using EGS (Millennium Ecosystem Assessment, 2005) as a deductive analysis framework, we developed a metric of importance based on how many farmers discussed a given EGS and how much, on average, that EGS was discussed by those farmers. A repeat visit in September added to the richness of the data pool and allowed us to test the influence of seasonality. Our motivating research questions were:

1. Which EGS categories do farmers associate with wetlands?
    a. Do farmer perceptions of EGS vary by wetland type?
    b. Do farmer perceptions of EGS vary seasonally?
2. Do the dominant wetland EGS perceived by farmers differ from those based on economic valuation?
3. What are the management and policy implications of farmer perceptions of wetland EGS?

4.3.1 Study Area

With some of the oldest farmland in North America, Nova Scotia's agricultural history dates back to the 17th century (Sherman Bleakney, 2004; Butzer, 2002). About 40% of all agricultural profits in Nova Scotia originate in the Annapolis Valley

(**Error! Reference source not found.**), which also has the province's highest density of farms per unit area (Nova Scotia Federation of Agriculture, 2001a, 2001b). It is bound by two small, linear mountains; the primarily granitic South Mountain (Ham & Horne, 1987) and the primarily basaltic North Mountain. This has led to the formation of fertile, well-drained soils containing mixed sedimentary and volcanic rock (White, 2009). These soil conditions contribute to a nationally significant fruit-growing region, and a considerable portion of the province's field crops and vegetables (Afolayan & Palermo, 1993).

Figure 10 A view of the patchwork of farms that make up the floor of the Annapolis Valley. Image: Wikipedia.org

High agricultural productivity has come with an environmental cost. Reports have estimated that 65% of salt marshes and 17% of freshwater wetlands have been lost in Nova Scotia since the arrival of the first Europeans, however these estimates are tenuous (Lynch-Stewart, 1983). Due to the extensive use of tile drainage by many Valley farms (Newell, 2002), the historical loss of wetland area in the Annapolis Valley is likely to be considerably higher than province-wide estimates, though this has never been quantified. In fact, the history of wetland conversion runs at least as far back as 1604 and the arrival of the Acadians from France (Griffiths, 2004), who used vernacular technology to drain salt marshes and create productive meadows (Bleakney, 2004; Butzer, 2002). Freshwater wetlands were also drained in NS as they were throughout large parts of North America where they were once considered “submerged farmland” and converted to monocultures of corn, soy and other cash crops (Irwin, 1985; Stunden Bower, 2011).

4.3.2 Determination of Wetland Types

In addition to the influence of the seasonal state of the local water regime, which we test through multiple visits, we hypothesized that the presence of surface water would be a potential source of influence on farmer perceptions. Incomplete knowledge of site characteristics such as soils, water chemistry, annual water regime, and history (particularly relevant to constructed wetlands) led to an *ad hoc* development of wetland categories based on conspicuous physical characteristics (Table 4). We thus used three distinct wetland types – farm ponds, open water marshes and covered marshes (no open water) - to compare farmers’ perceptions of EGS across a variety of wetlands common to the farm landscape. Here, we use the term ‘marsh’ colloquially as it doesn’t directly relate to marsh-type wetlands found in the Canadian Wetland Classification System (1997).

Table 4 Wetland classification scheme with biophysical attributes.

Characteristic	Farm Pond	Open Marsh	Covered Marsh
Surface water presence	Surface water present	Surface water present	No surface water present most of year
Vegetation	Sparse vegetation, usually only a ring of green around the water	Abundant emergent vegetation, submerged and floating aquatic macrophytes present	Hydrophilic plants dominate
Water Regime	Permanently flooded	Permanently flooded, intermittently partially exposed	Seasonally flooded, intermittently flooded, saturated soils throughout the year
Origin	Constructed for use as irrigation ponds, fire protection or other use	Natural or constructed but if constructed, much older and more naturalized than farm ponds (>30 years)	Natural in origin
Corresponding classification in Cowardin et al. 1979	Inland open fresh water	Inland shallow fresh marshes	Wet meadow, scrub-shrub swamp
***Canadian Wetland Classification System* (Warner & Rubec, 1997)**	Excluded from CWCS because they are primarily constructed	Basin marsh	Riparian shallow marsh Riparian shrub swamp

Wetland types used for stratification in the study did not correspond directly with classification schemes used by Cowardin *et al* (1979) or the Canadian Wetland Classification System (1997) but reflect a number of types included in these systems. *Open water marshes* and *covered marshes* were chosen to determine if the presence of surface water had an effect on how farmers perceived the wetlands; similarly we chose farm ponds (**Error! Reference source not found.**) because they are common in the Annapolis Valley landscape and are included in an on-going biophysical research project that used a similar classification system (Millet & Bondrup-Nielsen, 2013). Farm ponds were commonly created for fire prevention or irrigation, and often have little vegetation, sometimes even being mowed to the water's edge.

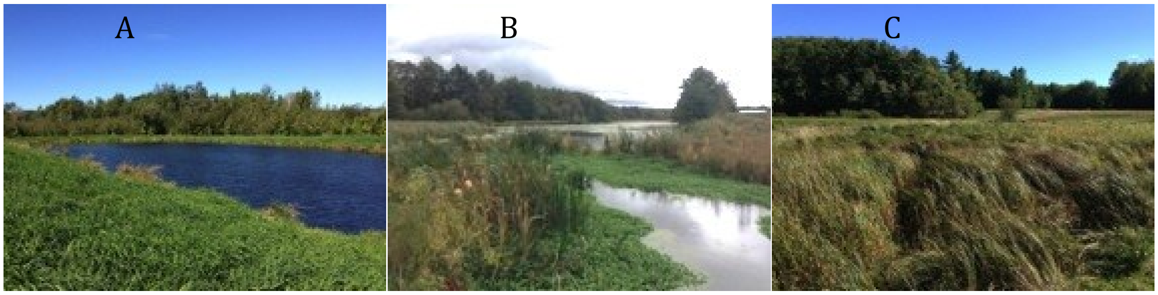

Figure 11 Wetland types used in this study a) farm pond, b) open marsh and c) covered marsh.

We used multiple wetlands on a single farm to maximize the number of wetlands included in the study (29) while keeping a manageable farmer sample size (19) (**Error! Reference source not found.**). During recruitment, we prioritized the identification of marsh-type wetlands, knowing they would be less common than farm ponds given the history of wetland drainage and pond creation in the region (Irwin, 1985). Farm ponds were present on most of the same farms.

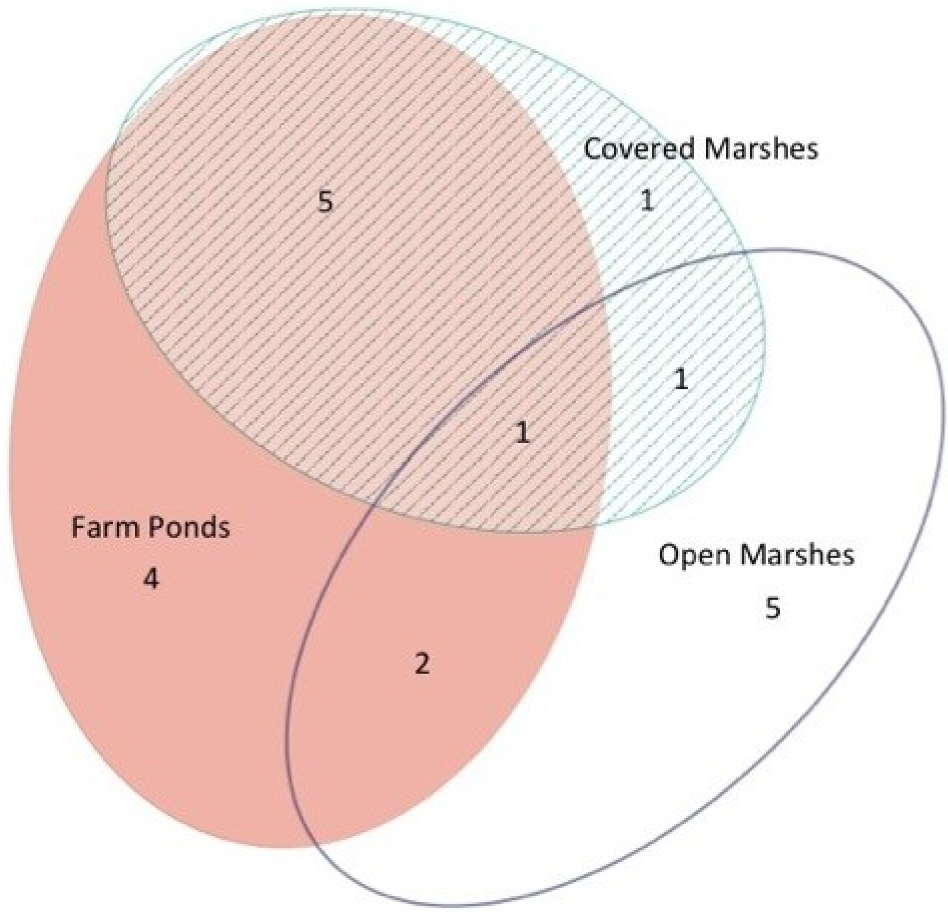

Figure 12 Venn diagram in relative proportions of the number of farm ponds, open marshes and covered marshes incorporated into this study. Overlapping areas represent the number of farmers interviewed regarding two (8) or three wetland types (1) on their farms. Figure created with eulerAPE http://www.eulerdiagrams.org/eulerAPE/

4.3.3 Participant Recruitment and Characteristics

All participants either owned or operated farms with wetlands within the Annapolis Valley. Aerial photography was used in conjunction with provincial wetland inventory maps (Nova Scotia Department of Natural Resources, 2004) to identify wetlands by type. We prioritized properties with more than one type of wetland that met our criteria. Property identifiers (PID) were used to identify the names of property owners via Property Online (Province of Nova Scotia, 2014), the provincial property database. Conventional methods (e.g. online phone books) were then used to find phone details for participants. On two occasions farmers had informally passed on their land to younger family members, in which case contact information was sought through the elder farmer.

During the recruitment process for the study, 37 farms were identified as potential sites. Of those sites, 27 were successfully contacted and 19 agreed to participate. Study farms were located in the Northwest portion of the Annapolis Valley where farms are most concentrated (Nova Scotia Federation of Agriculture, 2001b) and agricultural practices tend to be the most intensive (**Error! Reference source not found.**).

Participants were broadly reflective of normal demographic patterns within the farming community of Nova Scotia, except for sex ratio. All 19 participants were male, although females were not excluded from the study. Males dominate farming in Nova Scotia (75.3%; Statistics Canada, 2007), so it was not surprising to recruit a majority of male participants. Many of the farms represented by male farmers were co-owned and operated with females, but none participated in the interviews. Environmental perceptions sometimes differ between the sexes (Filipsson, Ljunggren, & Öberg, 2014), with females more 'environmentally friendly' (Wester & Eklund, 2011), but the distinction is not always clear (Lampkin, 2010). The sex imbalance may have affected our results and portray an overly negative or narrow view of wetland EGS, whereas a sample that included women may have resulted in more 'positive' results. Because the sex proportions remain the same (100% male) in May and September sampling results from the analysis of seasonality should not be affected by systematic bias.

Farmers' ages were reflective of the provincial average of 55 years (Statistics Canada, 2011) and was normally distributed around the mean category of 51-60 years but did include one young farmer (<30) and two older farmers (>70). The majority of participants had completed some university (n=10), while others had high school (n=4) or middle school (n=2) education. Three respondents did not report their education experience. Five participants indicated that they had attended agricultural college and had formally trained for careers in farming. The study population had more university graduates (42%) than the Nova Scotia average for farm operators (19%, Statistics Canada, 2006). Increased education has been associated with an increased willingness to sacrifice material wealth for the betterment of the environment and engage in sustainable practices and stewardship activities (Dietz, Stern, & Guagnano, 1998; Fielke & Bardsley, 2014; Huddart - Kennedy et al., 2009).

4.3.4 Field Method

Interviews lasted approximately 40 minutes and took place while standing alongside the study wetlands. The *in situ* interview style draws on previous findings that showed the use of visual prompts (e.g. photographs and *in situ* interviews) was effective in eliciting deeply held perceptions and values (e.g. Beilin, 2005; Owen et al., 2009; Sherren & Verstraten, 2013). Interviews were conducted in an unstructured manner, where questions posed were flexible prompts to guide the topics discussed; phrasing varied between interviews, but every attempt was made to ensure consistency in the meaning of the questions (Bryman, 2012).

We used standardized prompts to avoid the introduction of bias. Interactions with farmers were driven by the opening question and farmers were encouraged to respond freely, as is common with unstructured interviews (Bryman, 2012). All interviews began by asking each farmer to *"tell me about the area that we are standing in front of".* Other predetermined prompts included: 'how does this wetland impact you when farming?'; and, 'how does your farm impact the wetland?' (complete list – Appendix I), but most interviews required few prompts. When a farmer mentioned a given topic, additional prompts helped to clarify the context and inquire further into the meaning. For instance, if a farmer mentioned deer, we followed with a prompt asking if the deer used the wetland in any way. The same prompt was used anytime deer were mentioned in subsequent interview and with other participants. In this sense the prompts were developed *ad hoc*, but remained consistent. The unstructured style of the interviews allowed the farmer to guide discussion topics and provided a personal representation of factors important to farming with wetlands.

We used a second farm visit to enrich the data pool and to identify differences in perceptions based on season. This was important to determine if time of year influenced elicitation results. Most studies of landholder perceptions are based on a single sampling period, leaving questions about shifting landscape preoccupations largely unanswered. This is particularly important for wetland ecosystems because the services they provide, such as nutrient removal, vary seasonally (Jordan et al., 2003). Key parts of the nitrogen cycle, including nitrification and denitrification are temperature dependent reactions and thus the nutrient removal performance of wetlands may be reduced in seasonally cold conditions such as Nova Scotian winters (Gray; Kennedy & Mayer, 2002). Conspicuous changes such as the numbers of migrating birds may influence perceptions of wetland functions, which could have management implications for the promotion of wetland conservation.

4.3.5 Analysis

All interviews were transcribed *verbatim* and were analyzed using NVivo 10 qualitative data management software (QSR International Pty Ltd., 1999– 2014). We based our analysis and coding structure on the Framework for Ecosystem Goods and Services as described in the Millennium Ecosystem Assessment of 2005. While we followed the general structure of the EGS Framework, we also coded for negative services (disservices) and included 'habitat' as a provisioning service. The EGS framework by de Groot et al. (2010) uses habitat services as a foundational element that supports higher-level ecosystem services, thus classifying them as 'supporting' services. We include them as a provisioning service because farmers referenced habitat often as a direct wetland benefit rather than a "beneficial ecosystem process" (p. 262). We did not intend to calculate a total value of wetland EGS and therefore avoiding double counting was not a priority. For this reason and the context in which farmers mentioned habitat services, we included them under provisioning services.

Interview texts were analyzed sentence-by-sentence to identify any EGS discussed. For every instance where an ecosystem service was discussed, we noted whether:

- The stimulus for the comment was wetland ***or*** non-wetland; and
- The comment indicated a positive ecosystem service (presence of service) ***or*** ecosystem disservice

Although there is no standard procedure for dealing with the numerical outputs from qualitative analysis, our method attempts to control for variations in speaking styles and standardizes coded passage length. The method gives equal representation to all farmers in the sample and limits bias toward more verbose farmers and those who were interviewed about more than one wetland type or more than once.

Coded responses were tabulated and expressed in two ways: 1) the number of farmers who mentioned a given EGS in their interview(s) (n_f) and 2) the average character content, as a percentage of discussion about a given EGS ($\bar{x}$ or average content). We chose 'number of farmers' as an analytical unit to represent how widely a given EGS is recognized among the sample farmers. 'Average content' ($\bar{x}$) was calculated to reflect our assumption that farmers discuss topics that are important to them more than they do less important topics, but also to give each farmer equal representation within the sample. The percentage of coded transcript character content (x_{fi}) of each interview (i) completed with a farmer (f) was summed and divided by the number of interviews (n_i) to provide an average coded content for each farmer. This was done only with interviews that contained coded content of the EGS of interest ($x_{fi} > 0$), *i.e.* farmer interviews with null results for any given EGS were not included as part of averages. Averages were again summed and divided by the number of farmers (n_f) to achieve a weighted average that takes into consideration the length of interviews as well as the number of interviews completed with each farmer. The calculation to derive the weighted average can be expressed as:

$$\bar{x} = \frac{1}{n_f}\sum_{f=1}^{n_f}\left(\frac{1}{n_i}\sum_{x_{fi}>0}^{n_i} x_{fi}\right)$$

(1)

Although numerical analysis of qualitative data has been criticized for being a mixture of paradigms that neither respects the richness of interviews or satisfies the rigour demanded of numerical analysis (Williams & Patterson, 2007), it can be a useful and compelling tool to communicate results from complex analyses (Maxwell, 2010; Sandelowski, 2001). Numerical outputs are automatically generated by the preeminent software packages used for qualitative analysis and are likely influencing even studies that do not present that data numerically. Here, we use numbers to filter out key messages while providing clarity and transparency about their origins.

A high value for both number of farmers and average content is a suggestion that the EGS discussed is important. While average content ($\bar{x}$) is directly comparable between wetland types and seasons, number of farmers (n_f) is not, due to variations in the total sample sizes (n_t). Results were deemed notable if more than half of farmers mentioned a given EGS and the average content was greater than 6% $\left(n_{f \geq n_t/2} \cup \bar{x} \geq 6\%\right)$.

4.4 Results

This section reports the most prevalent EGS discussed by farmers, based on numerical analysis, along with details and indicative quotes related to individual wetland types and seasonal variation.

4.4.1 Overview

Provisioning services were the most commonly mentioned EGS categories (Table 5). When discussing provisioning services, positive narratives (n_f=19, $\bar{x}$=14%) were more common than negative narratives (n_f=9, $\bar{x}$=5%). The dominant provisioning sub-services elicited were *provision of freshwater* and *wildlife habitat* (Table 5). Positive narratives related to *freshwater provision* were elicited from 18 farmers ($\bar{x}$=7%) and negative narratives were discussed by 5 farmers ($\bar{x}$=3%). The importance of *freshwater provision* to farmers is mostly driven by their need for crop irrigation sources and water sources for livestock, while negative perceptions were based on water contamination that rendered the ponds unsafe for livestock. Positive narratives related to wildlife habitat were also common (n_f=18, $\bar{x}$=9%) and included the presence of attractive or desirable animals such as turtles. Negative narratives were less common (n_f=5, $\bar{x}$=3%) but related mostly to habitats attracting species with potential for crop damage. The recognition of *habitat provisioning* services was driven by conspicuous fauna such as ducks and geese (*Anatidae spp.*), as well as small mammals like muskrat (*Ondatra zibethicus*).

Table 5 Positive and negative farmer-discussed services by wetland type. Values given include average content, $\bar{x}$, with n-persons in parentheses (the number of farmers, n, interviewed for each type is shown parenthetically in the header). Appreciable results (substantial average content (≥6%) and over 1/2 of the possible farmers reporting that service) are bolded. Italicized results are mentioned in text, but do not meet both criteria for appreciable results.

	Farm Ponds (*n*=12)		Open Marsh (*n*=9)		Covered Marsh (*n*=8)		Total (*n*=19)	
Services	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive
Cultural Services (All services)	2.43 (3)	**11.7 (11)**	1.97 (2)	5.06 (6)	-	**7.57 (7)**	2.24 (5)	**9.45 (15)**
Aesthetic Values	3.46 (1)	**11.2 (7)**	-	2.21 (4)	-	3.43 (3)	3.46 (1)	**7.41 (11)**
Cultural Diversity	-	-	-	-	-	-	-	
Cultural Heritage Values	-	4.81 (5)	-	3.28 (3)	-	4.10 (4)	-	4.25 (10)
Educational Values	-	11.54 (2)	-	3.92 (1)	-	0.28 (1)	-	8.39 (3)
Inspiration	-	7.22 (3)	-	3.44 (2)	-	1.37 (5)	-	3.89 (9)
Knowledge Systems	-	-	-	-	-	2.41 (1)	-	2.41 (1)
Recreation and Ecotourism	1.91 (2)	**6.75 (9)**	1.97 (2)	3.02 (5)	-	**6.64 (5)**	1.94 (4)	5.65 (13)
Sense of Place	-	4.90 (3)	-	2.33 (3)	-	1.34 (5)	-	2.68 (8)
Social Relations	-	8.10 (4)	-	2.48 (4)	-	2.84 (2)	-	5.05 (9)
Spiritual and Religious Values	-	-	-	-	-	-	-	-
Provisioning Services (All services)	4.86 (6)	**20.5 (11)**	5.57 (4)	**10.53 (9)**	2.36 (3)	**10.22 (8)**	4.83 (9)	**14.38 (19)**
Biochemical medicines,	-	-	-	-	-	-	-	
Food and Fibre	1.76 (1)	4.15 (9)	5.53 (2)	1.41 (2)	2.36 (3)	**7.94 (7)**	3.30 (5)	4.9 (11)
Fresh Water	6.08 (3)	**8.0 (11)**	1.85 (3)	5.67 (8)	1.59 (1)	5.28 (4)	3.22 (5)	**6.74 (18)**
Fuel	-	-	-	-	-	2.58 (1)	-	2.58 (1)
Genetic Resources	-	3.25 (1)	-	-	-	-	-	3.25 (1)
Habitat Provision	2.36 (5)	**12.4 (11)**	3.04 (2)	**6.51 (9)**	1.02 (2)	**6.84 (6)**	2.56 (7)	**9.17 (18)**
Ornamental Resources	-	-	-	-	-	-	-	
Regulating Services (All services)	2.98 (8)	**8.49 (10)**	2.84 (1)	**6.94 (8)**	3.27 (3)	**7.58 (5)**	3.03 (11)	**7.04 (17)**
Air Quality Maintenance	-	-	-	-	-	-	-	
Biological Control	2.07 (3)	2.66 (2)	-	-	-	1.46 (1)	2.07 (3)	2.26 (3)
Climate Regulation	-	-	-	4.49 (1)	-	-	-	4.49 (1)
Erosion Control	-	5.23 (3)	-	**9.97 (4)**	2.03 (1)	2.48 (2)	2.03 (1)	7.09 (8)
Pollination	-	*10.79 (1)*	-	-	-	*28.32 (1)*	-	*16.63 (1)*
Regulation of Human Disease	2.75 (4)	2.66 (2)	-	-	-	-	2.75 (4)	2.66 (2)
Storm Protection	-	-	-	5.77 (1)	-	-	-	5.77 (1)
Water Purification and Waste Treatment	2.88 (4)	2.24 (2)	2.84 (1)	**6.33 (6)**	-	1.65 (3)	2.87 (5)	4.66 (10)
Water Regulation	3.24 (5)	**6.90 (10)**	-	4.56 (4)	3.88 (2)	3.64 (1)	3.49 (6)	**6.37 (12)**
Supporting Services (All services)	-	1.88 (1)	-	1.82 (2)	-	-	-	1.84 (2)
Nutrient Cycling	-	-	-	1.82 (2)	-	-	-	1.82 (2)
Primary Production	-	1.88 (1)	-	-	-	-	-	1.88 (1)
Soil Formation	-	-	-	-	-	-	-	

Cultural services were the second most commonly mentioned EGS category with the same pattern of positive narratives (n_f=15, $\bar{x}$=9.5%) outweighing negative narratives (n_f=5, $\bar{x}$=2%) (Table 5). Positive *aesthetic values* (n_f=11, $\bar{x}$=7%) and *recreation and tourism* (n_f=13, $\bar{x}$=6%) were the most common cultural services mentioned. *Cultural heritage values, social relations* and *inspiration* were also commonly mentioned (n_f=10, 9, and 9 respectively) but had $\bar{x}$ values of 5% or lower. Drivers of cultural EGS's were varied and highly context-specific, particularly with *inspiration* or *cultural heritage values* because farmers drew largely on unique past experiences.

Regulating services were the most balanced between positive (n_f=17, $\bar{x}$=7%) and negative (n_f=11, $\bar{x}$=3%) narratives, but positive still outweighed negative (**Error! Reference source not found.**). Sub-services that dominated regulating services focused on the role of wetlands in the regulation of water. Positive *water regulation* narratives (n_f=12, $\bar{x}$=6%) were twice as common as negative narratives (n_f=6, $\bar{x}$= 3.5%). Negative narratives were mainly driven by floodwater accumulation at wetland sites. Although farmers discussed wetland factors that mitigate floods, they often perceived wetlands as the origin of floods and therefore as the source of such ecosystem disservices. Narratives about *erosion control* were mostly positive (n_f=8, $\bar{x}$=7%), and focused on the ability of vegetation to hold sediments and filter moving water during precipitation events.

Only positive narratives were associated with supporting services but by a minority of farmers (n_f=8, $\bar{x}$=2%). Although wetlands are sites for *primary production* and *nutrient cycling* (Bernard & Solsky, 1977; Keddy, 2010), these were mentioned only briefly by very few farmers.

4.4.2 Variation Between Wetland Types

Comparisons between wetland types revealed differences in farmer perceptions of EGS. Generally, farm ponds elicited the most discussion while marsh-type wetlands evoked less (**Error! Reference source not found.**). Both positive and negative EGS were mentioned by all farmers in relation to all wetland types, but some EGS categories dominated discussion for certain wetland types (e.g. *food and fibre provision* from covered marshes).

4.4.2.1 Farm Ponds

Farm ponds elicited particularly strong responses related to provisioning services (n_f=11, $\bar{x}$=20.5%). Within the provisioning services, *fresh water* and *habitat provision* were the most frequently discussed (Table 5). Farmer responses about *water provision* were largely driven by the need for an irrigation source. For instance:

> This pond was constructed in the 1980's and built for irrigation purposes, it is kind of in a natural bowl. For that reason, it lent itself to the natural shape of the pond and we constructed the dam to catch some spring runoff and any other water that comes in the summer. Usually July and August is the dry period and that is when we need water for irrigation, we usually need quite a volume of water in those times (Farmer 13)

Often in conjunction with fresh water and other cultural services, farmers discussed conspicuous fauna species such as ducks. Most farmer discussion of ducks was quite positive and showed an appreciation for wildlife visitors to farm ponds:

> We got a good kick out of (the farm pond); there were two mothers and two males and they raised ducks here, six a piece and you could see them learning to fly from this end to that end, and swim back. (Farmer 1)

*Recreation and touri*sm (n_f=9, $\bar{x}$=6.8%) and *aesthetic services* (n_f=7, $\bar{x}$=11.2%) were the most commonly discussed cultural services associated with farm ponds. Recreation opportunities abound on farm ponds; fishing and skating were frequently mentioned. In addition to the leisure activities, the bucolic aesthetic of farm ponds was also appreciated:

> To me it is picturesque and I love to see the waterfowl and birds jumping in and getting the fish. (Farmer 4)

Codes often overlapped which is evidenced by the above two quotes which have aspects of habitat provisioning services, recreation & tourism as well as aesthetic services.

4.4.2.2 Open Marshes

Some regulating services were mentioned more in reference to open marshes than any other wetland type, specifically *erosion control* (n_f=4, $\bar{x}$=10%) and *water purification and treatment* (n_f=6, $\bar{x}$=6.3%) (Table 5). Commonly, *erosion* and *water purification* were equated with each other because farmers perceived both services as coming via the same process of sediment settling around emergent aquatic vegetation. In all likelihood, open marshes *are* providing more regulating services than farm ponds because of the increased residence time of the water in conjunction with increased physical complexity which slows water and facilitates settling (Coon, Bernard, & Seischab, 2000; Hansson et al., 2005; Kadlec & Wallace, 2008). This was reflected in farmer perceptions as evidenced by their discussion of open marshes and their ability to settle out run-off and thus mitigate erosion:

> These bulrushes are nice filters. The roots are such a great filter for catching sediment. Especially on that side of the (open marsh) where the water comes through the culvert from the field. It makes a nice filter (Farmer 13)

Interestingly, the wetlands that are likely the most effective at removing non-point source pollution are the covered marshes, due to their subsurface flows (Kadlec & Wallace, 2008; Mitsch & Gosselink, 2000b), but this is not reflected in the perceptions of the farmers.

4.4.2.3 Covered Marshes

Covered marshes elicited the most discussion about the provision of *food and fibre* (n_f=7, $\bar{x}$=8%) whereas other wetland types were dominant for other provisioning sub-services (Table 5). Farmers often mentioned animal grazing, either past or present, which was the primary driver for positive narratives regarding *food and fibre*. For instance:

> Years ago, cattle used to roam through here all the time. And now we don't do that. To me it was cleaner. In my opinion, it kept all the crap

> out of there because the cattle kept it beat down and chewed off. (Farmer 10)

Farmers discussed food sources such as trout in relation to covered wetlands but this can largely be attributed to brooks in close proximity to some covered marshes in the sample. As they are linked in the landscape, brooks and wetlands were often inextricable in the minds of farmers, however, covered marshes were not explicitly mentioned as nursery habitat for fish nor for their potential to contribute positively to landscape level water quality (Johnston, Detenbeck, & Niemi, 1990; Mitsch & Gosselink, 2000b). Fishing opportunities at brook-marsh complexes were also important as *food provision services* (n_f=7, $\bar{x}$=8%) and as *recreational services* (n_f=5, $\bar{x}$=7%):

> When I was a kid coming down here we would come fishing all the time. Between here and that road way you could get 2 or 3 12-14 inch trout. And for a brookie (Brook trout - *Salvelinus fontinalis*) that is big. And then it got to the point where we would release them. Then we had fun. It is good to eat them. (Farmer 1)

4.4.3 Temporal Variation

In both distinct periods of the water regime, positive discussion of EGS was more common than negative references (Table 6). Also, the most important EGS categories remained the same between the two sampling periods. However, differences did arise.

Table 6 Temporal variations between May and September responses. Values given include average content, $\bar{x}$, with n-persons in parentheses (the number of farmers, n, interviewed for each type is shown parenthetically in the header).

	May (*n*=19)		September (*n*=14)		Difference	
Services	Negative	Positive	Negative	Positive	Negative	Positive
Cultural Services (All services)	1.94 (4)	9.36 (15)	3.46 (1)	12.16 (8)	→	→
Aesthetic Values	-	5.85 (11)	3.46 (1)	9.55 (6)	↗	→
Cultural Diversity	-	-	-	-	-	-
Cultural Heritage Values	-	3.97 (9)	-	10.96 (2)	-	→
Educational Values	-	7.73 (3)	-	12.8 (1)	-	→
Inspiration	-	3.53 (9)	-	7.9 (1)	-	→
Knowledge Systems	-	2.41 (1)	-	-	↘	-
Recreation and Ecotourism	1.94 (4)	5.12 (13)	-	13.82 (5)	↘	→
Sense of Place	-	2.31 (8)	-	11.54 (1)	-	→
Social Relations	-	5.57 (8)	-	10.32 (3)	-	→
Spiritual and Religious Values	-	-	-	-	-	-
Provisioning Services (All services)	4.74 (9)	13.21 (19)	6.03 (5)	15.66 (14)	→	↗
Biochemical medicines	-	-	-	-	-	-
Food and Fibre	3.49 (5)	4.35 (10)	3.9 (2)	6.34 (4)	→	→
Fresh Water	2.95 (5)	6.3 (17)	9.04 (1)	10.55 (8)	→	→
Fuel	-	2.58 (1)	-	3.25 (1)	-	→
Genetic Resources	-	-	-	-	-	-
Habitat Provision	1.82 (6)	7.76 (18)	3.74 (4)	11.3 (11)	→	→
Ornamental Resources	-	-	-	-	-	-
Regulating Services (All services)	3.21 (11)	6.02 (15)	2.44 (2)	9.02 (10)	↘	→
Air Quality Maintenance	-	-	-	-	-	-
Biological Control	2.07 (3)	2.26 (3)	-	-	↘	↘
Climate Regulation	-	-	-	4.49 (1)	-	↗
Erosion Control	2.03 (1)	4.84 (4)	-	8.24 (5)	↘	↗
Pollination	-	17.01 (1)	-	1.88 (1)	-	↘
Regulation of Human Disease	2.85 (3)	2.66 (2)	2.43 (1)	5.77 (1)	↘	→
Storm Protection	-	-	-	-	-	-
Water Purification and Waste Treatment	3.2 (4)	3.16 (9)	2.44 (2)	9.89 (3)	↘	→
Water Regulation	3.49 (6)	5.76 (10)	-	5.39 (7)	↘	→
Supporting Services (All services)	-	1.27 (1)	-	2.13 (1)	-	→
Nutrient Cycling	-	1.27 (1)	-	2.38 (1)	-	→
Primary Production	-	-	-	1.88 (1)	-	↗
Soil Formation	-	-	-	-	-	-

→ Stable or inconclusive difference between May and September | ↗ Increase in response between May and September | ↘ Decrease in response between May and September

Many services, such as *aesthetic values*, *recreation and tourism*, *fresh water* and *habitat provision*, comprised a larger proportion of the September interviews than those in May although of a fewer number of farmers. This pattern was common between May and September outcomes and may have been an artifact of repeat interviewing. Because September participants had all been interviewed before, they had already been asked similar questions and formulated answers. It is possible that participants focused on elaborating upon previous answers rather than devising new responses. This is, in effect, a 'hardening' of opinions that results in stronger average content signals in September interviews than in initial interviews. If September interviews had been completed with 'fresh' participants that had not been interviewed already, results may not show the pronounced uptick in average content of important EGS. Conversely, it would be difficult to attribute the differences in results to the effects of conducting multiple interviews rather than variation in the sample of participants. There appears to be little research completed on the effects of repeat engagements on unstructured interviews but the results in Table 6 suggest that data comparability may come at the cost of data independence.

While most EGS categories showed greater average content responses in September this was not true in every case. The regulating service *biological control* made up a modest proportion of May interviews both as a positive and negative service, but was not mentioned at all in September interviews (Table 6). This could be because a substantial portion of discussion surrounding *biological control* focused on insects breeding in wetlands and the factors that controlled their population. Insects are much more prominent in the spring than they are in the late summer.

> There are a lot of swallows in the summer. They catch the mosquitoes. We have a lot of wind and that keeps the mosquitoes at bay as soon as the wind dies you see more flying around but when the wind blows they are not a problem. (Farmer 6)

Most discussions about insects were relatively pragmatic and balanced between negative (e.g. overabundance of pests, mosquitoes) and positive (e.g. abundance of pollinators), suggesting that insects may not be motivating farmers to eliminate wetlands from the landscape, or to restore or create them.

During May, wetlands elicited a greater amount of discussion about water regulation services and disservices. Water regulation disservices were pronounced in the spring season (n_f=6, $\bar{x}$=3%) but completely absent in the latter interview season. This suggests that farmers are associating wetlands with failures to regulate water when excess water is present. Such an association may be based on frustrations with wetlands as the sites of flooding rather than flood generators and is likely a result of wetland elimination elsewhere in the watershed.

4.5 Discussion

We set out to address some critical gaps in the literature by examining differences in farmer perceptions of EGS at three types of wetlands in different seasons. We aimed to identify management implications and policy recommendation to improve extension programs and ultimately improve wetland conservation outcomes.

Farmer perceptions identified in this study are consistent with the few similar studies found in the literature that show that farmers value many different EGS derived from wetlands. This paper, however, reveals considerable complexity in how farmers rank these services and the seasonal dynamics that affect those ranks. For instance, the most important wetland EGS categories from this study are; fresh water provision, water purification, habitat provisioning, which differ from both monetary studies (de Groot et al., 2012) and social studies (Brooks et al., 2014). It is evident from our results in Nova Scotia that not all wetlands are considered equal and some farmer perceptions do vary temporally, which has implications on future research and the broader field of agricultural extension. Here we discuss how EGS and elicitation approaches improve understanding of farmer perception of wetlands, and how certain farmer perceptions considered in conjunction with wetland attributes can be used to improve wetland conservation in the agricultural landscape.

4.5.1 Comparing Monetary Values and Perceptions of Importance

Our study is consistent with findings that show how socially determined values of wetland EGS are unique and not always aligned with monetary values. Specifically, this study suggests that farmers perceive the four most important wetland EGS to be:

1) Habitat,
2) Freshwater provision,

3) Aesthetic values and
4) Water regulation

This is contrasted with economic valuations that show the four most valuable wetland EGS are:

1) Water regulation,
2) Waste treatment,
3) Erosion prevention and,
4) Recreation

(de Groot et al., 2012).

Differences in units make direct comparison impossible but it is clear, through ranking that the perception-derived importance of EGS categories does not always align with monetary values.

Costanza *et al.* (1997) show the extraordinary value of some wetland services such as water provision ($7,600/ha/year) while others pale in comparison (food production - $47/ha/year). Unfortunately, there is a paucity of information that suggests a ranking or organization based on social perceptions and non-monetary valuation for comparison. In the studies that have been completed on non-monetary values of EGS, particularly those involving farmers (*e.g.* (Brooks et al., 2014; Smith & Sullivan, 2014) results are dissimilar from the existing monetary valuations. Brooks et al. (2014) similarly found that farmer (and fisher) perceptions in Asia, assembled through a non-monetary approach differed substantially from the assessed values of wetland EGS (Figure 13). Furthermore, economic analysis showed that only very few services were of considerable value, whereas stakeholders tended to value many different wetland EGS. This has implications for wetland managers because it allows extension efforts that leverage social perceptions to use a wide variety of EGS. Promotion of EGS through their monetary values only makes sense for the few most valuable EGS (*e.g.* water supply, flood control, and water treatment) (Figure 13).

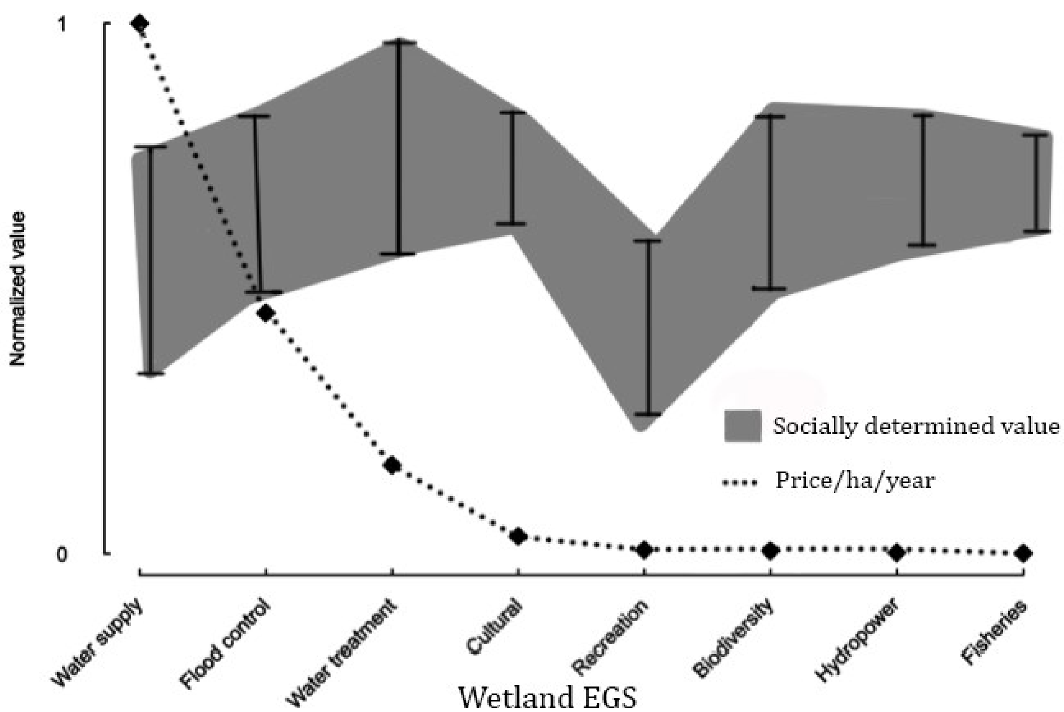

Figure 13 A comparison of normalized values of wetland ecosystem goods and services determined through economic analysis and social study (focus groups). Adapted from Brooks et al. (2014).

4.5.2 Insights for Ecosystem Managers

4.5.2.1 Farm Ponds and Aesthetics

There are some interesting signals for managers and policy-makers in the way that farmers in this study perceived the least ecologically intact ecosystems - farm ponds - as the providers of the most EGS. Cultural services were associated with farm ponds by nearly every farmer interviewed. *Aesthetic values* were important for other wetland types too, and were mentioned in an overwhelmingly positive manner. Aesthetics has been shown to play a considerable role in management decisions on farms (Gobster, Nassauer, Daniel, & Fry, 2007), and is important to both rural and urban dwellers (Nassauer, 1989). Similar to members of the public (Junker & Buchecker, 2008), farmers favour landscape descriptors such as 'neat', 'natural' and 'scenic' (Nassauer, 1989). The strong association of *aesthetic values* and farm ponds is potentially explained the balance between 'naturalness' and 'neatness': they are typically neatly manicured to have less natural vegetation than other wetland types. Landscape aesthetics are highly contextual and can represent a strong attachment to the landscape and in turn, the ecology of the landscape (Gobster et al., 2007). While *aesthetic values* may seem comparatively disconnected from on-farm ecology, for farmers it can serve as a conceptual linkage between farm operations and conservation-worthy ecological processes (EGS) (Gobster et al., 2007).

Preference for 'naturalness' and 'neatness' in farm ponds suggests avenues for more effective conservation. The manicured style of farm pond edges could provide an 'orderly frame' to the 'messy ecosystem' within; constructing a cultural (agricultural) framework around ecological processes (Nassauer, 1995). An important consideration is how the aesthetic appeal of farm ponds might be leveraged into the conservation and restoration of natural wetlands. Advocating a completely passive 'rewilding' of wetland areas – a process of restoration defined by natural processes rather than human preferences (Monbiot, 2013) - may be less effective than strategies that promote a compromise between 'neatness' and 'naturalness'. Espousing certain beneficial practices that can be construed as 'neat', such as hedgerows and linear vegetated buffers could contribute to wetland conservation goals.

4.5.2.2 The Historical Context and Relating Perceptions of Covered Marshes

The association of covered marshes with food and fibre provision – particularly the grazing of these settings – provides managers opportunities to leverage historical practices (Verhoeven & Setter, 2009) in the pursuit of efficient conservation and to identify contentious issues that will prevent such conservation. Although grazing covered marshes is much less common than it once was, in part due to extension efforts (e.g. Harris, 2010), it is still an important historical narrative associated with the landscape. Research suggests that cattle exclusion is generally good for wetlands and streams (Miller, Chanasyk, Curtis, Entz, & Willms, 2010; Schwarte et al., 2011) and has been a focus of conservation schemes (Fitch, Adams, & O'Shaughnessy, 2003; Newell, 2010). However, farmers didn't always agree that exclusion was a positive contributor to environmental quality:

> …the issue that I have, is people blaming the cattle for eroding the brooks. But oh my goodness, you look through there where the brook is and that brook was honestly not more than eight inches wide, and four feet deep [years ago]. Well, cattle aren't [eroding the brook]. (Farmer 10)

While farmers' traditional knowledge is not infallible (and is subject, as with anyone's, to exaggeration), it is important for conservation managers to monitor and understand the socio-historical context in which farmers make land management decisions. Increased understanding of social contexts can shed light on ineffective extension programs and resistance to regulatory mechanisms (policies, regulations and legislation). Associations such as these may be good fodder for education programs, but also potentially further research into the risks and benefits of grazing such wetlands.

4.5.2.3 Surface Water and the Perception of Water Functions

Many of the EGS that were widely regarded as important by the farmers in this study were closely related to water, including fresh water, water regulation and water purification and waste treatment. Farmers deemed these services more important around farm ponds and open marshes – the two wetland types with open water – than around covered marshes. In the case of all three water-related services, a fewer number of farmers discussed them in regards to covered marshes. This could suggest that water truly is "out of sight, out of mind" for farmers. Covered marshes with subsurface flows are efficient assimilators of waste (Kennedy & Mayer, 2002) but are not perceived as such by farmers, which could have implications for wetland creation. Currently, farmers may be more likely to construct treatment wetlands for farm run-off if surface water will be present and visible, however it may not be an effective solution. Wetlands featuring slow-moving subsurface flows and emergent vegetation such as cattails are relatively cheap and can be designed to treat specific waste types such as agricultural wastes (Gray, 2008). Educating farmers to this end could promote the use of treatment wetlands while protecting natural wetlands from agricultural run-off.

4.5.3 Insights for Researchers

This section discusses the implications and opportunities presented by the methods used in this study and others.

4.5.3.1 Elicitation Approaches

Elicitation approaches can be useful in determining social perceptions because they place control in the domain of participants, and limit the bias inherent in direct questioning. We found that recording and measuring the EGS discussed by farmers in unstructured dialogue allowed for the elucidation of deep-seated values that drive farmer behaviour. Consideration of ecosystem services and disservices in isolation from each other ignores the dynamic system of trade-offs and competition that farmers must navigate in making farm management decisions. Recent studies on farmer perceptions of EGS importance using Likert-scale surveys have not been able to effectively determine a reliable ranking of importance due to skewed data (farmers consistently assigned the maximum value possible) (Greenland-Smith, 2011; Smith & Sullivan, 2014). This may be partially due to social desirability bias (Crowne & Marlowe, 1964; Fisher & Katz, 2000), whereby participants respond with answers that they perceive as correct. Research methods to understand these complex drivers of perceptions should use methods that force choices via some constraints: in our case, this was the trade-off between topics of conversation within interviews. Our results thus avoid the inflation of EGS perceptions that arise from questionnaires (e.g. Smith & Sullivan, 2014).

4.5.3.2 Temporal Variation and Multiple Visit Methodologies

Although overall patterns between the two distinct sampling periods were similar, the differences we observed suggest that it may be important to consider timing (e.g., seasonal environmental conditions) when planning studies based on elicitation of perceptions. EGS typically associated with the seasonal water regime (water purification, water regulation, biological control of insects) experienced the greatest differences between sampling periods. The benefit of *in situ* elicitation techniques is that the results are highly associated with the condition of the sample area, including seasonal conditions. Conditions of the water regime (and hence water related EGS) must be factored into study design to ensure that perceptions at any given time don't misrepresent the perceptions over time. This is particularly important with studies that aim to capture perceptions of highly season factors such as EGS. Our study demonstrates the importance of considering temporal dynamics including seasonality, and potentially multiple visits, something that is seldom done in elicitation studies. Alternatively, if only on visit is possible, that visit should be scheduled according to the characteristics that are of most interest to researchers. For instance, if management of drought conditions is the primary line of inquiry, wetlands should be visited during the driest part of the year.

4.5.4 Recommendations for Policy Directions

Regulators or policy-makers can capitalize on agreement between farmers' perceptions by targeting extension programs toward already well-recognized (socially and economically) EGS such as water provision (Brooks et al., 2014). By contrast, when farmer perceptions are not in alignment with valuation literature, policies can guide extension programs to focus resources and address knowledge gaps. We believe that both of these avenues are better informed by increased qualitative study of farmer perceptions.

Based on our findings and relevant literature, we propose four recommendations that we anticipate will further the goals of agricultural wetland conservation and in turn bolster the EGS derived from wetlands.

1. Expand research about farmer perceptions in relation to EGS. Incorporation of this social data will improve the efficacy and efficiency of agricultural extension programs (Greiner & Gregg, 2011).

   Social perceptions of EGS are just beginning to mature as a field of inquiry, but have already delivered some useful results. Economic valuation does a good job at capturing a certain type of value but money cannot be the sole unit of analysis for the value that humans place on the environment (Spash, 2007). Expanding research avenues for social perceptions within the EGS framework will add richness to economic valuation and may expose gaps in the transition between monetary valuation and conservation.

2. Encourage wetland conservation through the promotion of EGS where perception-based, science-based *and* monetary values align. These EGS include water provision (Brooks et al., 2014) and water regulation (Liu et al., 2010).

   The scientific literature is full of recommendations to capitalize on 'win-win' situations. Most of these involve situations where the economics of conservation actually encourage practical measures toward conservation. However, the recommendation made here is slightly different. Even though some conservation practices have been deemed profitable to farmers such as water quality management and integrated pest management, not all farmers engage in the practice (Cooper & Keim, 1996). Instead of targeting areas of overlap only between profitability and conservation, it may be more feasible to encourage behaviours when conservation, profitability and social perceptions are favourable. In Nova Scotia, research is still lacking on the profitability of individual conservation recommendations (such as those from Agricultural Biodiversity Conservation plans) but promoting conservation practices that target the creation of fresh water provision, and early season water regulation while also creating habitat will support EGS that farmers already associate positively with wetlands.

3. Where perceptions of EGS, biophysical performance and economic profitability do not align, an opportunity exists to emphasize certain EGS categories in extension programs to conserve specific wetland types, such as provisioning

services for covered marshes and farm ponds, and regulating services for open marshes.

For example, organizations such as DUC promote wetland conservation and creation. To improve their efforts they should promote the EGS that are most positively associated with the wetland type that they intend on building. For the most-part DUC constructs small ponds with lots of open water that often mature into open marshes once vegetation becomes established. In the lead-up to the construction of these marshes they should promote the ability of such wetlands to provide habitat, fresh water and recreation opportunities, as well as their regulating benefits such as water regulation, waste purification and erosion control.

4. Advocate practices that capitalize on farmers' preferences, rather than being ecologically idealistic. Many beneficial management practices might also appeal to the 'neat' and 'manicured' aesthetic preferences of many farmers (Junker & Buchecker, 2008) such as wind-breaking hedgerows and vegetated buffers (Harris, 2010). Thus, education about EGS benefits of hedgerows and buffers could have a higher probability of resulting in farmer adoption of these practices.

Promoting a balance between practices that are beneficial to the environment and appealing to farmers is a common-sense idea, however this balance is not always navigated properly. Consulting with farmers in an engaging process is also a learning experience in and of itself that can generate 'buy-in' to programs that would otherwise be unappealing to farmers if it were simply imposed upon them. Farmers are key stakeholders in the promotion of programs and potentially valuable resources to disseminate information; they should be fully engaged in determining which solutions effectively strike a balance between achieving conservation goals and being palatable to farmers.

4.5.5 Directions for Further Study

This research was specific in its investigation based on three main research questions, but is broadly applicable because of the framework and methodology used. Opportunities for further study abound, including that already mentioned into the perceptions of female farmers, and expanding the research to include other geographies. Completing a similar study in an agricultural area with even great wetland loss such as Ohio or even SW Ontario may provide insights into some of the social legacy impacts of wetland drainage. Additionally, measuring farmer perspectives in areas with very low wetland drainage would provide an interesting comparison that could further explain how farmers perceive and adapt to the loss of EGS from the landscape.

While the study presented here provides a catalogue of farmer perceptions associated with wetlands, the drivers of these perceptions remain unclear. Investigation of the specific demographic factors of farmers (income, education, family history, sources of information *etc.*) and specific wetland attributes (size, depth, age, maturity, shape, proximity to residences, proximity to recreational space *etc.*) could contribute to a more fulsome understanding of the complex dynamics between farmers and wetlands. Previous studies have focused on factors leading to farmer adoption of beneficial management practices (discussed in section 2.5) but few study social perceptions and none deal exclusively with wetlands.

Unstructured interviews are rich reflections of personal opinion and deeply held values, which lend themselves to inductive analysis. Unfortunately, time constraints prevented any inductive analysis in this study. It would be interesting, to analyze the interviews from this project through an inductive lens to identify differences between deductive coding (using the *a priori* EGS framework) and inductive coding (developing an *a posteriori* framework). This would also provide a more in depth look at which specific sub-services were mentioned the most and the context in which they were mentioned.

Conducting similar studies on other ecosystems would also help illuminate which ecosystems are associated with which EGS in the landscape. Farmers commonly interact with and manage tracts of forest land, which provide a unique set of EGS compared to wetlands. Identifying both divergent and common elements between perceptions of each ecosystem could shed light on any EGS that are just inherently valued by farmers and which are ecosystem specific, contributing to more effectively targeted extension efforts.

As further research illuminates farmers' social perceptions about EGS, proponents of conservation will be able to take full advantage of the synergy provided by knowing the human-held values of EGS as well as the economic values. Together they can be used to create efficient and effective extension programs to realize wetland conservation goals and maximize on-farm EGS production.

Chapter 5 Conclusion

Our results provide evidence that farmers hold a nuanced view of wetlands that considers both wetland type and temporal variation. Farmers primarily recognized EGS associated with water, specifically water provision and water regulation, but also recognize various disservices. EGS is a powerful boundary concept that lies between academic disciplines, bringing them together to achieve societal goals. However, to date the social sciences remain much less commonly employed. Our case study of the Annapolis Valley, NS provides results that echo economic valuation and biophysical studies in asserting the critical importance of wetlands but also suggests held values associated with EGS that are not easily reconciled with monetary assessments (cultural heritage values, social relations). We believe that an increased understanding of the social contexts and perceptions surrounding wetlands and the EGS they provide can better inform agricultural extension programs and in turn improve wetland conservation in agricultural landscapes.

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Appendix I – Interview Prompts

School for Resource and Environmental Studies
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Interview Guide

This interview guide is meant to present the style and content of the interviews. It is not an interview script and the actual interviews may digress slightly from the guide. Values, including those held by farmers, are deeply held constructs based on many experiences. For this reason, values are not accessible by means of transparent questioning or surveying. Some questions may apply to some participants and not others and questioning will vary because the physical wetlands themselves are being used as prompts for the interviews.

Preamble

Thank-you very much for agreeing to take part in my study, it will really help my research. Because the topic of my research is on farmer views on wetlands, I would actually like to conduct the interview in front of the wetland to help us both to think of things to talk about regarding the wetlands. The interview will be very informal and most of my questions will be based on your specific wetland, but I will have a couple of questions for you that I will be asking everyone in the study. I expect the interview to last about 30 minutes or a little longer including time to walk or drive to the wetland area. Again, you are free to end the interview at anytime if you feel uncomfortable. This interview will be confidential and I will be the only one who would be able to match what you say with the interview data.

When the interview starts you may talk about whatever you think it important about the wetland. There are no right or wrong answers and I will just be asking questions to figure out your views on wetlands. You knowledge and expertise as a farmer about the wetland is really what will help me meet my research goal and I'm very interested in what you have to say. If you feel uncomfortable with any questions, you don't have to answer them and we will move on.

I would like to record the interview so my data is as accurate as possible. That way I won't have to take notes and it will be easier to carry on our conversation. Do I have your permission to record the interview? I won't use anything you say without your permission. Would you consider wearing a microphone?

For each wetland site, I will ask :

	Farm Visit 1	Farm Visit 2
Discussion point		
1	**"Tell me about this wetland"**	**"Tell me about this wetland"**
Prompt	"Where does it drain to?"	"Does this wetland dry up?"
2	**"Have you changed this area at al?"**	**"How has this area changed since the spring?"**
Prompt	"How long has it been like this?"	"Is this condition pretty typical for the season?"
3	**"Why have you left this area like this?"**	**"Does this area change much on its own?"**
Prompt	"Would you ever consider changing this area?"	"Is this area predictable?"
4	**"How does this wetland impact you when farming?"**	**"How does this area impact you while farming in the summer?"**
Prompt	"Is this area an issue when farming?"	"Is this an area of concern during the summer?"
5	**"During this time of the year what is the usual condition of this wetland?"**	**"During this time of the year what is the usual condition of this wetland?"**
Prompt	"Has it always been that way?"	"Has it always been that way?"
6	**"Does this area benefit your farm?"**	**"Does this area benefit you during the summer?"**
Prompt	"How do you use it?"	"Differently than it does in the Spring?"
	"Does it benefit people other than you?"	"Who benefits from this area in the summer?"
7	**"Does this area directly harm or hinder your operation on farm in any way?"**	**"Does this area hinder you in the summer, as far as farming goes?"**
Prompt	"What does this area cost you?"	"Why is it bad/not-so-bad in the summer?"
	"Does it harm or hinder anyone other than you?"	
8	**"Is this area interesting to you?"**	**…during summer"**
Prompt	"Do you like this part of your farm?"	…during summer"
9	**"Does this wetland affect what you can do with this part of your land?"**	**"Does this area help you maintain water levels during summer?"**
Prompt	"How does it help or challenge your farming practices?"	"How does it help or challenge your farming practices during summer?"

10	**“How does the surrounding area affect your wetland?”**	
Prompt	“Do you think it is pretty natural?”	
11	**How do you imagine this area in the future?**	

Is there anything you would like to tell me that I didn’t ask you?
Can you show me any other areas like this on your property?

Conclusion

I want to thank you so much for being a part of my research and helping me out. It has been fun learning about your farm and your wetlands. I’m looking forward to our next engagement. If you have any questions for me I’d be happy to answer them, or if you think of anything at a later time you can always call me or send me an email. The information you have provided will be used to better understand how farmers view wetlands, and I thank you for contributing. I will send you a copy of our interview when it is transcribed into text for your review. Even though our interview is finished, you can always request to have your data removed from the study. If you are interested in the publications that result from the study I’d be more than happy to share them with you via email or regular mail.

Appendix II – Letter of Participant Contact

School for Resource and Environmental Studies
Suite 5010, 6100 University Ave
Faculty of Management,
Dalhousie University
Halifax, NS, B3H 4R2

Letter for first contact

Date

Dear Participant, (to be personally addressed)

My name is Simon Greenland-Smith, I'm a graduate student at Dalhousie University and I'm conducting research as part of my Master's degree in Environmental Studies. For the past 3 years I have been studying agriculture in Nova Scotia, specifically the low-lying parts of the landscape with wetlands like bogs, swamps and marshes. During my undergraduate degree (also at Dalhousie) I conducted a survey with about 125 farmers: thanks if you were one of those who filled one out. That survey answered a few questions about land management around wetlands but it also left me with more questions.

To answer some of these remaining questions I am conducting interviews with farmers to get a more in-depth look at how they view on wetlands on their properties. I think my study will contribute to a greater understanding of the 'people' side of the issues facing farmers and their properties. I am asking each participant in the study to conduct 3 interviews with me throughout 2013. Each interview will last about a half-hour during a different season: spring, summer and autumn.

To be eligible for the study you must have some type of wetland on your farm and actively farm some or all of your land. Your participation in the study is totally voluntary and you can choose to end your participation at anytime. If you are interested in lending your expertise to my study, I would be so thankful, and you can let me know by mail, email or phone. Please contact me if you have any questions about my research or if you know anyone else who might be interested in helping me in my research. The Dalhousie University Research Ethics Board has approved my research, as has my supervisor, Dr. Kate Sherren (kate.sherren@dal.ca).

Thanks again, I hope you will consider contributing to my research.

Simon Greenland-Smith

School for Resource and Environmental Studies (SRES)
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902 402 9545

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Appendix III – Informed Consent Form

School for Resource and Environmental Studies
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Dalhousie University
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Informed Consent Form

Understanding how farmers view wetlands in agricultural Nova Scotia

Dear Farmer, (to be personally addressed)

I hope you will consider lending your knowledge and expertise to my study by participating in my research. This document explains any risks or inconveniences that you might experience during the course of the study. These risks are expected to be minimal. While the study is not likely to benefit you directly, your participation will help me as well as future researchers to learn how farmers view wetlands. Please contact me if you have any questions my research or the research process (my information is below).

Your participation in the study 100% voluntary and you may choose to end your involvement at any time. If you would like to stop taking part in the study please contact me at any time. The interviews will be confidential and nothing you say will ever be linked to your name or other identifying information. Once the interviews are complete you will be given a chance to look over a copy of the interview once it is transcribed into text. You can opt into or out of having quotes used in our research results on the consent form that appears later in this document.

Scope

Each participant will be asked to lead a short farm tour to the wetland or wetlands identified from the maps and will be asked to engage in an informal interview about their views on wetlands. The interviews will take place in spring, summer and fall and can be arranged at your convenience. Each interview will take about 30 minutes and will cover topics about how each farmer uses their wetlands. In the summer, we hope to also undertake a brief wetland vegetation survey, which will make that interview longer by about 20 minutes. When the interview recordings are transcribed into text you will have an opportunity to review the text and ensure that it is accurate, this task is expected to take about an hour. If you are interested, I will also provide you with a list of interesting species or plants and animals found in your wetland. The total time commitment for participation in this project is around 4 hours, spread out over 9 months.

Possible risks and discomforts

Risks and discomforts are expected to be minor to minimal. The interviews will take place outdoors, near the wetland(s) on your property. There are risks associated with being close to water but every precaution will be taken to ensure your safety. In the case of storms and other poor weather conditions interviews can be rescheduled at your convenience.

Possible benefits and results

This study is not expected to provide any direct benefits to the participants. However the results of the research could indirectly benefit the larger farming community in Nova Scotia. The results will help understand farmers' views on wetlands which are valuable in creating more practical and Nova Scotia appropriate stewardship programs. I plan on sending each participant a brief report on the results of the research and if you are interested I can mail or email a copy of any reports that result from the research.

Confidentiality & anonymity

All participants who are part of this study will remain anonymous in all the reports and publications that result. Your name and personal information will not be released to anyone and I will be the only one with this information. Each participant will receive a number, which identifies them and will be used in all data processing instead of your name. All recordings of interviews and other information will be kept on a password protected computer and physical copies will be kept under lock and key. All photographs will only be taken with permission and will be used to identify wetland type and some wetland plants and animals, these photos may also be use for final reports and presentations. Dalhousie University Policy on Research Integrity requires that all data be securely maintained by the university for 5 years after it is used. After this time, it will be destroyed.

If you agree to let me use any quotes from the interviews in reports or publication, I will not attach your name or any other identifying information (such as farm characteristics) with those quotes. I will send you the interview transcripts by mail or email (your preference) so you will have the chance to review the interview text before any quotes are used to make sure you are being quoted accurately.

Questions

If you have any questions or concerns about the project or the process please contact me, Simon Greenland-Smith by email (s.greenland-smith@dal.ca) or phone at 902 402 9545.

Problems or concerns

If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director, Research Ethics, Dalhousie University for assistance at (902) 494-1462, ethics@dal.ca. You can also contact my supervisor, Dr. Kate Sherren at kate.sherren@dal.ca.

Thanks again for your time,

Simon Greenland-Smith
Master's of Environmental Studies Candidate

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Understanding how farmers view wetlands in agricultural Nova Scotia.

Informed consent

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions (if any) have been answered to my satisfaction. I hereby consent to take part in this interview. However I realized that my participation is voluntary and that I am free to withdraw from the study at any time. I consent to participate in this interview process under the conditions stated above, with the specific permissions indicated below.

I receive a portion of my income (even a small portion) from farming.	**Yes**	**No**
I am the owner or co-owner of the land where the wetland of interest is located, or I manage it under a formal agreement such as a lease.	**Yes**	**No**
In order to ensure the accuracy of my interview, I consent to an audio **recording** being made of the interview by Simon.	**Yes**	**No**
In order to supplement recordings, I consent to some **photographs** being taken by Simon during the interview. (Anything you don't want photographed for any reason, just say so and it will not be photographed at all.)	**Yes**	**No**
I consent for **photographs** of my property taken by Simon to be used in publications/presentation.	**Yes** No need to ask	**No** Do not use any
I consent for direct **quotes** from the interview to be used <u>anonymously</u> in reports and publication	**Yes** No Need to ask	**No** Do not use any

Participant Name: ____________________ Signed:____________________________

Date: ___________________________________

Researcher: Simon Greenland-Smith Signed:

____

902 402 9545 Date: ___________________________________

Appendix IV – Demographic Information Collection Form

DALHOUSIE UNIVERSITY
Inspiring Minds

School for Resource and Environmental Studies
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Faculty of Management,
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Halifax, NS, B3H 4R2

Demographic information collection sheet

To better understand your answers in the interview portions of the study, it is important that we know a little about you and your farm. Please answer the questions as best you can, if there are any questions that you do not wish to answer, or feel uncomfortable answering leave the question blank. **Remember that all answers are anonymous; your name will never appear with these answers in any presentations or publications. The only thing linking you with your answers is your Farmer Identification Number. Only Simon has access to the information that links your name with your ID number.**

1. How old are you? under 30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-70 ☐ over 70 ☐

2. You are: male ☐ female ☐

3. What is the highest level of formal education that you have completed?

☐ Grade 9 or less	☐ Some university
☐ Some high school	☐ University degree (Bachelors)
☐ High school graduate	☐ Some graduate study
☐ Technical school or Community college	☐ Graduate university degree (Masters or PhD)

4. Did your farm register a profit in 2012? ☐ yes ☐ no

5. What is the approximate size of your property? ______ acres ______% in production

6. Which category best describes your farm? What commodities do you produce? (Check all that apply)

☐ Field Crops	☐ Garden vegetables	☐ Dairy
☐ Cattle	☐ Horticulture	☐ Fruit
☐ Forest Products	☐ Other Livestock	☐ Other ______________________

7. Anything you would like to add? Please use the space below.