Institute for Sustainable Finance

The Wealth of Wetlands

Measuring the Economic Value of Two Critical Ecosystem Services in Canada

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EXECUTIVE SUMMARY

Nature's value to humans is immense. Our economy and even our existence depend on the health of the environment around us. Despite this dependence and our collective tendency to measure value, we have limited knowledge and experience applying economic estimates to nature.

This paper focuses on wetlands, which are considered the world's second-most valuable biosphere after coral reefs. Even a partial assessment of Canadian wetlands' value, provided by this paper, reveals they likely provide natural services worth around $225 billion per year, equivalent to around 10 percent of GDP.

Canada is blessed with vast wetlands but they have been disappearing quickly, often converted to farmland and urban development with little thought to the natural service they provide, which can include flood prevention, erosion prevention, wildfire suppression, irrigation for crops, habitat for valuable species, and recreation. In particular, this paper focuses on two natural services by wetlands that can be measured using "directly observable market prices": water filtration and carbon sequestration.

There are some significant challenges in valuing wetlands services, which emphasizes the need for further study by the Institute for Sustainable Finance. One is that we do not have a clear picture of how much wetland we have in Canada, and where. This is an alarming situation given the pace of wetlands destruction and the value they provide. Wetlands' value also varies significantly by type and location. Bogs, fens, swamps and marshes all contribute to the economy in different ways. Water filtration and flood prevention services are more valuable near urban areas. Estimates of carbon sequestration benefits vary widely and again depend on the type of wetland.

However, it is clear that wetlands in Canada provide enormous value that doesn't appear on any balance sheets, yet! This is a major missed opportunity considering the many potential advantages of Canada's incredible natural endowment.

Value of water filtration services: Wetlands are excellent at filtering out pollutants before they reach lakes and rivers, something that is costly to do with man-made technology. Calculating the average of estimates for value provided per hectare per year, and using existing low-resolution satellite mapping for an estimate of wetlands coverage, we can find an aggregate value of roughly $201.8 billion (CAD 2023) each year for water filtration services of wetlands in Canada.

Value of carbon sequestration services: Wetlands can also act as carbon sinks, providing the vital service of removing carbon dioxide from the atmosphere, which mitigates global warming. Using accepted measures of the social cost of carbon and the net carbon sequestration capacity of Canadian wetlands, we estimate an annual Canada-wide value of wetlands' carbon sequestration services of roughly $21.8 billion.

Investing in nature-positive outcomes: Maintaining the integrity of intact wetlands and restoring degraded ones requires significant capital output. However, investing in conservation and restoration also presents many potential benefits including improved asset quality, portfolio diversification, long-term returns from asset value appreciation, alleviated future resource scarcity and regulatory change risks, access to tax benefits, and lower costs.

There are a number of potential areas of capital sourcing for preserving natural assets such as wetlands reviewed in this paper: Green bonds; Environmental Impact Bonds (EIBs), payment for ecosystem services models; Voluntary Carbon Markets (VCMs), biodiversity credits (similar to carbon credits), blended financing models and tax incentives.

A vital next step will be to develop more accurate estimates of total coverage of wetlands and other beneficial ecosystems, combined with thorough evaluations of their derived services. This will be a major area of focus for ISF. Until we can establish the economic contribution of Canada's natural spaces such as wetlands, hundreds of billions of dollars in value could be wiped out without properly accounting for it, leaving us all much poorer.

ACRONYMS

ES = Ecosystem Service

SEEA–EA = System of Environmental-Economic Accounting — Ecosystem Accounting

SCC = Social Cost of Carbon

CO2eq. = Carbon Dioxide Equivalent

TNFD = Taskforce on Nature-related Financial Disclosures

> Mires . . . moors . . . muskegs . . . peatlands. . . wetlands — all these terms describe areas that are waterlogged all or most of the time. They are neither firm "lands" in the conventional sense nor bodies of open water; hence they occupy a transitional position between land and water. The ecosystems that develop on such lands are dominated by the persistent presence of excess water. Wetland is defined as "land that has the water table at, near, or above the land surface or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to the wet environment" (Tarnocai 1980).[1]

INTRODUCTION

Natural ecosystems and their "services" such as water filtration, climate regulation, and flood protection, are critical to human existence and well-being. Despite the assets and derived services' contribution to human welfare, decision-makers (including individuals, firms, and government) regularly do not account for their value. Furthermore, the absence of nature and ecosystem services in most national balance sheets can lead to the exploitation and degradation of the natural world. Simply put, accounting for an increase in GDP while omitting a corresponding depreciation of natural capital leaves us with a gaping hole in our accounting methods and understanding of costs incurred.

Nature is a broad term. To help understand how humans interact with, manage, and value nature it is helpful to break it up into its component ecosystems and ecosystem services. In this report we give an overview of research that places an economic value on nature, specifically, wetland services. We also discuss wetland management and policy, and estimate economic flow values of wetlands in Canada for two core wetland ecosystem services — carbon sequestration and water filtration.

We arrive at our estimate using the benefit or value transfer method, and focus on wetland services with a directly observable market price. This limited us to two services: CO2eq. net exchange with the atmosphere (includes carbon sequestered and methane leaked), and water filtration. We find a surprisingly wide range of values for both wetlands CO2eq. net exchange and wetland coverage estimates.

The water filtration provided by wetlands is extremely valuable, but highly dependent on the wetland's location. We also find that our country severely lacks an understanding of our current stock of natural capital (including but not limited to wetlands). While models of wetland land cover exist, their accuracy is generally poor. Our understanding of the spatial distribution of wetlands across the country is therefore limited, as are estimates of total wetland area.

VALUATION

Valuations of nature help convey to both technical and non-technical audiences the scale of our economic reliance on nature. Ecologists, biologists, and professionals in other related disciplines understand how fundamentally important various ecosystems are to our daily lives. However, a large portion of our population does not have this knowledge and may not understand the full value of nature. By presenting this information in monetary terms — something almost everyone is familiar with — we can quickly convey the value of nature to a much wider audience.

Decisions often reveal how something is valued, and when a municipality or landlord makes a decision for land they oversee, an implied valuation takes place. Private landowners usually convert wetlands (often into agriculture) based on an expected increase in economic returns from the trade-off — influenced by both policy and market forces.[2]

The valuation of nature is unavoidable — ecosystems and their services are valued every time we make a decision involving trade-offs concerning them;[3] subsequent decisions are then made based on this type of faulty and incomplete data, perpetuating the undervaluation of nature.

This cycle will continue until a more accurate and holistic valuation scheme is developed.

VALUATION METHODS

There are several methods for valuing ecosystem services. There is, unfortunately, little consistency in how each method is defined by researchers and sometimes concepts are mixed up under different names. In this section we mostly defer to The System of Environmental-Economic Accounting — Ecosystem Accounting (SEEA–EA) as it was adopted as an international statistical standard by the United Nations Statistical Commission in March 2021.[4] Statistics Canada also bases its Ecosystem Accounts on the SEEA–EA framework.[5] Below is a table that outlines several valuation methods for ecosystem services using the SEEA framework in order of preferred method.[6]

TABLE 1

Preference order and valuations by SEEA EA

SEEA EA preference order	SEEA EA Method Category	Methods	Example
1	Prices are directly observable	Market prices	Use market prices observed in emission trading schemes to value the carbon sequestration of wetlands
2	Prices from similar markets	Similar markets	Observing the cost of using cultivated bees and other pollinators in place of wild pollinators (similar markets)
3	Prices embodied in market transactions	Residual value; resource rent; hedonic pricing; productivity change	Productivity change method can be used to estimate the value of soil erosion control by assessing the gains in yield from reduced erosion that is attributable to a particular ecosystem
4	Price from revealed expenditures on related goods and services	Averting behaviour; travel expenditure	Survey or sales data tracking the amount consumers pay to visit a nature site can be used to derive willingness to pay and a demand curve for recreational ecosystem services
5	Prices from expected or simulated expenditures or expected markets	Replacement cost; avoided damage cost; simulated exchange value	Use the cost of replacing an ecosystem service such as water filtration using alternative means

Source: SEEA, Valuation of Ecosystem Services and Ecosystem Assets, **Table 1**. Modified from source.

For a more detailed and technical breakdown see the Valuation Methods section of the Appendix.

THE VALUE OF WETLANDS

Wetlands provide value in many different ways, and the way each living thing on Earth may value wetlands varies greatly: As a vital source of clean water and air, as a hunting grounds, or as a home, to list a few. In this report we focus mainly on how humans value wetlands. Some services that wetlands provide include: biodiversity, habitat, carbon sequestration, water filtration, recreation, food, and flood prevention. Other ecosystems, such as forests, would also provide some of these services. An overview of the natural services that wetlands provides can be seen in **Table 2** below.

TABLE 2

Overview of Wetlands' Natural Services

Natural Service	Description
Water Filtration and Regulation	• Remove excess materials (phosphorous, sediment, etc.) • Break down compounds
Carbon Storage and Sequestration	• Remove and store carbon dioxide from the atmosphere
Flood Prevention and Mitigation	• Store excess water during periods of significant precipitation • Regulate water flows
Soil and Sediment Regulation	• Accumulate organic materials • Erode rocks
Wildlife Refuge	• Provide habitat for local species to live and procreate
Provisioning Raw Materials	• Source of lumber • Source of food (berries, rice, shellfish, etc.) (United States Environmental Protection Agency, 2023)
Pollination and Nutrition	• Allow for the movement of biological materials necessary for reproduction
Recreational Activities	• Sports (fishing, boating, etc.) • Eco-tourism
Cultural Activities	• Contribute to visual identity of a community • Academic study • Scientific research • Religious/spiritual significance

Note: Adapted from Costanza et al. (1997)[7]

The idea of valuing wetlands and nature more broadly has not been widely popularized, but it is not new. In 1988, the Sustainable Development Branch of Environment Canada released Wetlands of Canada in the Ecological Land Classification Series.[8] In their book they state:

> "The overall national economic values attributable to wetlands in each of these sectors, as summarized in Table 10-15, amount to $5-10 billion in total annually. This is a significant component of the nation's total economy which has not generally been appreciated."[9]

Environment Canada's review assessed sectors including recreation, water purification, shoreline protection, flood peak modification, and several others. The book's release and findings are significant, demonstrating that this type of economic thinking existed more than three decades ago.

Stanford's Natural Capital Project, co-founded by Gretchen Daily, has been studying this for decades. Notable publications include *Nature's Services: Societal Dependence on Natural Ecosystems* (1997) and *The New Economy of Nature: The Quest to Make Conservation Profitable* (2002).[10]

In 1997, Costanza et al. released *The Value of the World's Ecosystem Services and Natural Capital*, where they estimate that wetlands are one of the most valuable biomes on a per hectare annual basis at \$14,785 (1994 USD ha^{-1} yr^{-1}) (\$37,250.11 CAD 2023).[11] For context, this same paper valued forests at \$969 (1994 USD ha^{-1} yr^{-1}) (\$2,441.34 CAD 2023).

In 2014, Costanza et al. estimated the value of the world's global ecosystem services again, using some methodology changes, new ecosystem service values, and land change estimates between 1993 and 2011. Their estimate on a per hectare basis for wetlands increased from \$20,404 to \$140,174 (2007 USD) (\$30,934 to \$212,513 CAD 2023).[12] This estimate is based on wetland subgroups where tidal marsh/mangroves increased from \$13,786 to \$193,843 (\$20,900 to \$293,879 CAD 2023) and swamps/floodplains decreased from \$27,021 to \$25,681 (\$40,966 to \$38,934 CAD 2023). These revised estimates place wetlands as the second most valuable biome on Earth on a per hectare flow value annual basis, only being surpassed by coral reefs.

The value of wetlands and natural services more generally can be sensitive to their location or proximity to a city. Ideally, we could adjust values of wetlands to reflect location, but due to current data constraints this isn't possible — a limitation suffered by all previous studies. We hope that future research advances this area and makes the relevant data available, so more accurate valuation estimates can be made.

VALUING WETLAND SERVICES

Given the abstract nature of valuing some of nature's services, along with their associated wide valuation ranges, we choose — at least in this initial report — to focus on valuing wetland services that have a directly observable market price. This valuation method is the most preferred method for valuing ecosystem services outlined by the UN and the SEEA.

The SEEA outlines tiers of primary valuation methods by each ecosystem service. Of the 21 services they outline, only two apply to wetlands and have the directly observed price method listed. These two services are carbon sequestration and water filtration. It's important to note that these two services have different beneficiaries. In the case of water filtration, the benefits are localized, whereas the benefits of carbon sequestration are enjoyed globally and can be considered a public good. It is important to consider who receives benefits from each ecosystem service when designing policy that ensures the longevity of our natural capital.

Before looking at how these services are valued on a per-hectare basis, let us look at estimates for wetland coverage, a core piece of information for a country-wide estimated value.

WETLAND AREA ESTIMATES

The exact amount of wetland coverage in Canada isn't known, so we will consider a range of estimated values. The Canadian Wildlife Service has estimated total wetland coverage to be 129,018,700 ha.[13] To contrast this estimate, we measured 56,893,293.72 hectares of Canadian wetland using a 30-meter resolution land cover map of natural assets across North America produced in 2020 by the Commission for Environmental Cooperation (CEC). [14] The coarse granularity of this map limits its accuracy, but higher resolution maps of natural assets covering Canada currently do not exist. Development of high-resolution mapping techniques would have great value, enabling more accurate estimates of coverage.

Researchers and government departments have studied wetlands within specific ecozones across Canada with a wide range of results, which can be seen below in **Table 3**.

TABLE 3

Wetland Area Estimates for Canada

Wetland Area Estimates

Source	Year	Context	Area Estimate (ha)
Commission for Environmental Cooperation	2020	Canada — all ecozones	56,893,293.72
Environment and Climate Change Canada (2016)[15] referring to Canadian Wildlife Service (2016)	2000	Canada — all ecozones	129,018,700
Ontario Ministry of Natural Resources and Forestry (2017)[16] — referencing Ontario Biodiversity Council (2015)	Unknown	Northern Ontario — Hudson Bay Lowlands ecozone (57% of Ontario's wetlands)	20,000,000
Ontario Ministry of Natural Resources and Forestry (2017)	Unknown	Southern Ontario	1,000,000

To calculate a Canada-wide value for wetland services we will use estimates from the CEC because the Canadian Wildlife Service estimate is probably too high (it relies on data from around the year 2000 and wetland destruction has occurred continuously between then and now).

The wide range in estimates of the total area of wetlands in Canada is a limiting factor when attempting to estimate their aggregate value. More generally, there is a great importance in developing up-to-date and accurate estimates and making them available for incorporation into decision making.

CARBON SEQUESTRATION

To value wetlands' carbon sequestration service, we would ideally take a range of CO2eq. net exchange rates found in the literature. To our surprise we find a very wide range of rates, implying that wetlands range from being sinks (net CO2eq. intake) to sources of CO2eq., especially when incorporating the leakage of methane. This is both concerning and important as it signals that different types of wetland may have different capacities for climate regulation. However the explanatory variables here have not been identified; it's unclear whether attributes such as the biodiversity or health of a wetland are most salient, or if a finer breakdown by ecological class (bog, fen, swamp, marsh, shallow water) would best explain the variance observed in wetland CO2eq. net exchange.

For illustrative purposes, we take an average value amongst sources that estimate wetlands as net sinks of CO2eq. and incorporate both carbon sequestered and methane leakage rates. We also obtain these estimates from research papers that examine wetlands found in Canada or similar to Canada's. [17] This approach allows us to have more control over the valuation method as we can ensure that methane rates are incorporated and a consistent economic value is applied for each tonne of CO2eq. sequestered. Methane is important to consider because only measuring carbon would lead to a siloed, incomplete picture of how wetlands overall help to regulate our climate. The estimates used can be seen in **Table 4** of the Appendix.

We then can multiply this net CO2eq. rate by an economic value for each tonne of CO2eq. sequestered. For this, the SEEA recommends using the price of carbon observed in an appropriate market for the country of interest.[18] Since Canada does not have this (Canada has a carbon tax but not country-wide and mature carbon market), we are left with using the social cost of carbon (SCC).[19] Using a 2% near-term Ramsey discount rate, the 2023 SCC is $261 (2021 CAD) as stated by Environment and Climate Change Canada (ECCC) and used by Government of Canada departments and agencies.[20] This value is set to rise to $394 in 2050.

This choice of discount rate may seem low, and the reasoning is explained in ECCC's report: "Due to the especially long intergenerational analyses required to comprehensively evaluate climate change impacts on society, a lower discount rate is justified to reflect intertemporal trade-offs more accurately over longer time horizons."[21] The report included tables of SCC estimations corresponding to 1.5%, 2%, and 2.5% rates. At a 2.5% discount rate the SCC for 2023 is $160 which highlights its sensitivity to the chosen interest rate. For further context, one carbon credit in the EU Emissions Trading System (EU ETS) as of June 2023 was around $140 CAD.

Taking the average CO2eq. sequestration rate and converting to a hectare level we get 2.4 tonnes per hectare per year. Using the total estimated wetland coverage of 56,893,293.72 hectares measured from CEC's land cover map, we get 136.5 million tonnes of CO2 eq. To put this number in perspective Canada's GHG emissions were 670 Mt of CO2eq.

Using the 2023 SCC value of $160, we estimate an annual Canada-wide flow value of wetlands' carbon sequestration services of roughly $21.8 billion CAD.

WATER FILTRATION

Wetlands' water filtration capabilities are valuable for helping make water usable for humans and industrial purposes. For example, a 2021 study from the University of Waterloo has estimated the water filtration value of wetlands in Southern Ontario at $4.2 billion per year ($5.2 billion CAD 2023) for the region.[22]

When estimating these values at a global scale, estimates have a large range. For instance, when estimating global wetland water filtration rates Schuyt & Brander (2004) estimated $259/ha/year (CAD 2016) ($318 CAD 2023)[23] while Costanza (1997) estimated it at $7,977/ha/year (USD 1994) ($20,098 CAD 2023).

The range of estimates demonstrate the difficulty in formulating one central valuation methodology. Many factors influence these numbers, including geographic location, proximity to an urban area, ecological class (bog, fen, swamp, marsh, shallow water), water filtration efficiency achieved, and local costs of replacing the functionality with artificial means.

To estimate the value of this natural service, we take an average of estimates made in a Canadian context (see **Table 5** in the Appendix), resulting in $3,547 per hectare per year (CAD 2023). Using the area estimate measured using CEC's land cover map, the aggregate value is $201.8 billion (CAD 2023) for water filtration services of wetlands in Canada.

FINANCING CONSERVATION AND RESTORATION

Maintaining the integrity of intact wetlands and restoring those which have degraded to their former state requires significant capital output. Investing in conservation and restoration presents many benefits for individuals and firms. These include improved asset quality, portfolio diversification, long-term returns from asset value appreciation, alleviated future resource scarcity and regulatory change risks, access to tax benefits, and lower artificial processing costs from natural assets providing services.[24]

A promising area of capital sourcing comes from outcome-based financing models. Under this system, involved parties think that natural assets will provide tangible value and they are willing to pay for them.[25] Payments are made based on meeting targets set before or at the time of investment. Some examples of outcome-based financing are Environmental Impact Bonds (EIBs), Payment for Ecosystem Services (PES), and Green Bonds.

GREEN BONDS

Green Bonds are "fixed-income securities that raise capital for projects with environmental outcomes".[26] They tend to have a short to medium term focus with 79% being less than 10 years long. Green bond principles dictate essential elements of the investment agreement, including the use and management of proceeds, project evaluation and selection, and reporting requirements. Most green bonds "for sustainable land use and conservation to date have been based on the full faith and credit of the issuer" due to the fact that it is difficult to "articulate a steady stream of cash flows from these projects."[27] The Government of Canada issued its first green bond in March 2022, shortly after publishing its Green Bond Framework.[28] The bond was priced at $5 billion, had a 7.5 year maturity period, and ended with a final order book of $11 billion. According to an Allocation Report, $160.2 million of the raised funds were given to Habitat Conservation and Protection to help during the 2021–2022 fiscal year to "secure, protect, connect, improve and restore ecologically sensitive habitat, including wetlands."[29]

ENVIRONMENTAL IMPACT BONDS (EIBS)

EIBs differ from Green Bonds in many ways; significantly, EIBs involve more risk-sharing and link investor returns to the achievement of measurable environmental outcomes. Within this framework, gains exist for all involved stakeholders. The asset owners or partner payors benefit "sooner from protections to assets provided by wetlands" and see reduced business disruptions and lower long-term risks.[30] Investors get to view the "measurable impact of investments" and "receive a bonus performance payment" if the project exceeds its targets. Communities benefit from job creation through contractor hiring and see more money flowing into their local economy.

PAYMENT FOR ECOSYSTEM SERVICES SYSTEM

Under a Payment for Ecosystem Services (PES) system, "landholders or managers are paid for the successful provision of certain ecosystem services by users or beneficiaries of these services".[31] The amount provided is mainly determined by the party's willingness to pay. The main barriers to this framework are the complexities of setting it up and negotiating payment amounts. Some examples of PES are in Costa Rica, where the State provides direct payments to the owners and holders of forests and forest plantations for the environmental services they provide (carbon sequestration, biodiversity protection, water regulation and landscape beauty).

Challenges involved with PES include the burden of monitoring and the possibility that it crowds out intrinsic values of conserving different ecosystems. Canning et al. (2021) proposed an innovation within PES by asserting they should use Common Asset Trusts (CATs).[32] This is where several wetlands that maintain or improve natural services are combined into an investment portfolio with shared ownership and decision-making power.

VOLUNTARY CARBON MARKETS (VCMS)

Another financing method that has grown significantly in recent years is voluntary carbon markets. This system allows "carbon emitters to offset their unavoidable emissions by purchasing carbon credits emitted by projects targeted at removing or reducing GHG from the atmosphere".[33] This is done completely on the own volition of organizations usually to meet their net zero goals as part of ESG initiatives and exists outside of compliance-based carbon markets. These credits can sometimes help restore or conserve ecosystems, especially when the ecosystem is a powerful net carbon sink.

BIODIVERSITY CREDITS

Biodiversity credits are part of a newer credit-based system which aims to more directly affect nature. These credits are developed when a company identifies threatened habitats and forms a partnership with owners of the land. A big difference from carbon credits and a core challenge is the lack of clear metrics to measure biodiversity outcomes.

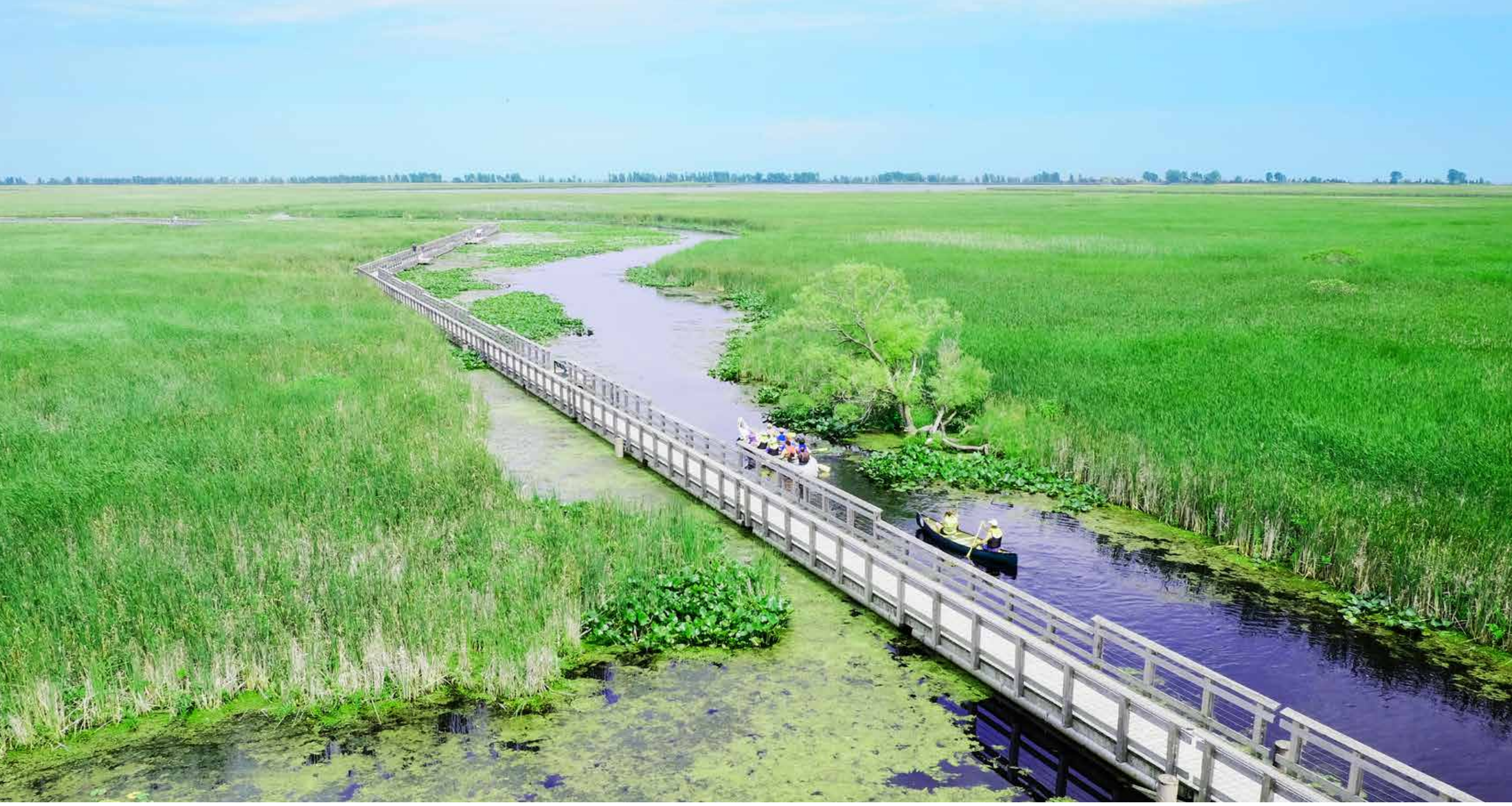
Both carbon credits and biodiversity credits are subject to the additionality test which means that the intervention "would not have occurred under a business as usual scenario."[34] In other words, for the credit to be valid it must have *caused* the reduction of carbon emissions or positive biodiversity outcome. Overall additionality is hard to model and prove, often leading to exaggerated claims. Furthermore, a lack of regulatory oversight can lead to low-quality credits where the claimed environmental results and what occurred, in reality, do not match. Other issues include meeting the permanence criteria which must show that "projects need to minimize the risk that future developments will reduce or remove the benefits delivered."[35]

BLENDED FINANCING AND TAX INCENTIVES

It is also important to acknowledge the role governments can play within private investments for conservation and restoration. Catalytic/blended financing uses private capital and public grants together in order to help reduce the risk faced by investors.[36] This can be viewed as a form of anchor investing, where large institutions make a significant contribution in order to enhance the appeal of a financial instrument to other investors. Another tool governments have at their disposal is tax incentive programs, where property taxes paid by private land owners are partially reduced or completely eliminated in exchange for conservation activities.

Mitigation potential and cost differences across wetland conservation and restoration activities should be considered in the capital allocation process. Drever et al (2021) find that avoided peatland conversion has the highest annual mitigation potential in Canada, yet is relatively expensive with no mitigation available at less than CAD $100 per tonne C02eq.[37] However, the next largest wetland opportunity is avoided conversion of freshwater mineral wetlands, all of which is available for less than CAD $50 per tonne CO2eq. Of all the options this paper estimates, they find that avoided conversion activities have a significantly larger amount of mitigation potential compared to restoration.

For more information on restoration methods, best practices, results and cost estimates on a per hectare basis, see the Wetland Restoration section in the Appendix.



LIMITATIONS AND VALUATION CONCERNS

The valuation of ecosystem services is not without concerns or issues. One main limitation is our lack of understanding of the extent, type or ecological class, and location of the wetlands in Canada. Currently available estimates are out of date, lack data granularity, or are confined to a small region. To build on this, a wetland's attributes and its location have a large influence on its economic value; the absence of these data points hinders our value estimates. Beyond wetland area estimates, high variance of both net CO2eq. rates and economic estimates makes arriving at an exact estimate difficult.

Some argue that the economist approach in placing monetary values on the environment is too human-centred.[38] There may also be too much uncertainty involved, subjectivity, or lack of precision for some to deem the exercise worthwhile. Yet, implicit valuation of the environment continues, and often, it is ignored, vastly underestimated, or just not properly accounted for in land management decisions. Placing nature in economic terms — a language familiar to decision-makers — can help bring it to the forefront and not be forgotten when consequential choices are made. Moreover, the ability to measure our current stock of nature can help us manage it and make more informed decisions.

There is also a notion that valuation of nature creates perverse incentives because if you destroy it the remaining parts increase in value. We acknowledge this could exist in theory but believe that, in most cases, the market power of one entity would have limited influence on its overall value. Further, there is a perverse incentive to associate zero or little cost to nature destruction or deterioration. A carbon tax places a cost on every tonne of CO2eq. emitted. This system — where externalities have a cost — does not currently have an equivalent for the cost to society of destroying nature.

And finally, optimizing the value of one ecosystem service without considering other factors can lead to unfavorable outcomes. For example, planting one species of tree to maximize carbon sequestration may mean water usage is relatively high. This monoculture tree plantation can also pose serious forest fire risks, which is important given the consideration of permanence for carbon removal.[39] Furthermore, monoculture means low biodiversity. Biodiversity is especially difficult to value; policy makers should be wary of this, particularly when high-value ecosystem services are not also ones with high biodiversity. The valuation of nature based on biodiversity is beyond the scope of this report. Overall, our focus thus far on two wetland services gives us a limited understanding of wetlands' economic value.

WETLAND DESTRUCTION

Despite their high estimated value, wetlands have been, and continue to be, destroyed at a rapid pace. More than half of the historical wetland area in the United States has been lost due to anthropogenic activities.[40] The Ramsar Convention of Wetlands report in their Global Wetland Outlook that approximately 35% of the world's wetlands were lost between 1970-2015 and the loss rate has been accelerating annually since 2000.[41] Historic annual rates of loss for wetlands are also over three times faster than those of forests.

In 1991 the Government of Canada estimated that more than two-thirds (68%) of the wetlands once present in southern Ontario no longer exist.[42] They also find that "The greatest single threat to wetlands historically has been drainage for agricultural purposes, accounting for 85% of total known conversions. Urban growth and industrial expansion account for an additional 9%." The conversion of wetlands to alternative uses in the agriculture sector is often an economic decision based purely on the expected gains from both options. Developing mechanisms that can bring the true value of wetlands to the decision-making process can help with conservation and restoration efforts.

The private sector is also beginning to take note of the value of nature, its destruction, and the risks posed if not managed correctly. This is highlighted by the creation of the Taskforce on Nature-related Financial Disclosure (TNFD) whose mission is:

> "To develop and deliver a risk management and disclosure framework for organizations to report and act on evolving nature-related risks, with the ultimate aim of supporting a shift in global financial flows away from nature-negative outcomes and toward nature-positive outcomes."[43]

Overall, the creation of TNFD and the subsequent expected increased consideration for the natural world is a positive sign because it means more informed decisions can be made.

CONSERVATION AND RESTORATION WETLAND POLICY

The Canadian government has been involved with wetland management for decades. The first policy came in 1973 with the passing of the *Canada Wildlife Act* which aimed to protect animals and habitats.[44] Section 3 of the associated Wildlife Area Regulations contained key takeaways such as only issuing activity permits if the benefits of activities "outweigh any adverse effects", showing that the government is beginning to incorporate the adverse effects of losing a wetland into decision making.[45] In 1991 the government came out with another policy covering wetland loss mitigation, enhancement, and rehabilitation efforts.[46] The government also underscored the importance of wetlands by estimating their $10 billion (or $19 billion CAD 2023) in yearly economic returns throughout the country, which appears to be the first time an economic value was assigned to wetlands in Canada. This figure was calculated by compiling the estimates from previous reports, articles and statements and extrapolating the results on a time-adjusted national scale. These included the values of goods and services provided by wetlands on a total or per hectare basis.

Overall, wetland policies in Canada have seen both advancements (in terms of stringency) and setbacks that threaten the health and existence of our wetlands. There has also been the emergence of wetland restoration financing and policy, as compared to just preservation. The forces of economic development on one side and wetlands preservation and restoration on the other have long been pulled in opposite directions. We hope the positive economic value of wetlands is increasingly incorporated into the financial decision-making process of land management.

CONCLUSION

Wetlands are a valuable resource that provides critical environmental services in Canada and around the world. The destruction of wetlands over the past several decades as part of development and agricultural practices has made remaining wetlands even more valuable. Governments, organizations and researchers have taken note of these facts and are prioritizing activities to preserve and restore these natural wonders.

To improve these efforts, further research needs to be conducted to determine a standard valuation framework of quantifying the positive effects of wetlands. Focusing on the accurate valuation methodologies in different ecozones for specific ecosystem services provided, as well as developing area estimates that take into consideration the everchanging conditions of the environment, will be critical in formulating next steps. The end goal of the research is to provide all stakeholders with more information so better land-use decisions can be made.

Knowing the risks and rewards of different development and conservation activities is paramount to ensuring the well-being of both people and the environment.

APPENDIX

VALUATION METHODS

What follows is a list of valuation methods outlined by SEEA.

Market prices

The use of market prices or directly observed values is the most direct method for estimating values of ecosystem services. Stumpage (the price on standing timber and the right to harvest it) is an example of directly observed values. This method can and should be used any time there is a market for the ecosystem service of interest. The size and maturity of a market should also be considered when using this method as immature markets may have volatile prices. For example, the price volatility of carbon credits found in the EU carbon market may make it inappropriate for valuing rates of carbon sequestration.

Similar markets

If there is no appropriate market for a particular good or service then the valuation may be derived from a market price of a similar good or service by adjusting for quality and other differences. [47] A most common example of this method is for the estimation of imputed rent for owner-occupied dwellings where the observed rents paid by tenants are used after adjusting for the associated location and characteristics.

Resource rent and residual value

The SEEA states "The residual value and resource rent methods estimate the value for an ES by first taking the gross output value of the final marketed good to which the ES provides an input, and then deducting the cost of all other inputs, including labour, produced assets and intermediate inputs." For example, this method could be used for crop and wood provisioning services and would involve subtracting labour and depreciation of fixed capital.

Productivity change

The productivity change method (sometimes called the production function method) requires using micro-level data and econometrics to estimate the marginal productivity of ecosystem service inputs(s). Once the marginal productivity is determined it can be multiplied by the output price to arrive at the exchange value of the ecosystem service. This method could be used to measure how wetlands' water filtration abilities directly affect the cost of producing municipal drinking water as improved water quality leads to reduced water purification costs.

This method could be used to measure how wetlands' water filtration abilities improve water quality and thus reduces water purification costs involved with producing good municipal drinking water.

Hedonic pricing

The hedonic pricing method involves estimating the premium on property values derived from their proximity to some environmental attribute (e.g., a local park, water of a lake etc.). To single out the effect of the environmental attribute on the property's price, all other price influencing factors (e.g., number of bedrooms, square-footage, etc.) should be incorporated into the statistical modelling process. In essence, this method involves the use of econometrics to single out the effect that an environmental attribute has on a property's value.

Averting behaviour

The averting behaviour method is based on community and individual level spending that reduces or eliminates damages from adverse environmental impacts. For example, this could include extra filtration for purifying polluted water, or machines to filter polluted air. This method has an advantage in that it is easier to estimate expenses incurred than to estimate avoided environmental damage. One advantage of this approach is that it uses data on actual expenditures. However, this method is also restricted to cases where those affected are fully aware and have information on the environmental issue/impact and act because of them.[48]

Travel expenditures

The travel cost valuation method is based on the costs incurred by households or individuals to reach an ecosite and hence receive an ecosystem service, usually in the context of recreation activity. There is general agreement that this method is effective and well-suited for valuing recreation services for welfare analysis (Bockstael and McConnell, 2007).[49] This method also demonstrates that different ecosystem services require, or have, different, appropriate valuation methods.

Replacement cost

The replacement cost method, sometimes also referred to as the substitute or alternative cost method, according to SEEA uses the "expected cost of replacing a single ES using a process that provides the same benefits but for which there are established costs or prices." Replacement costs should also not be mixed up with restoration costs since restoration costs, implicitly, cover all ecosystem services unlike replacement, which focuses on just one.

The SEEA also outlines that the validity of the replacement cost method depends upon three main conditions: the substitute can provide precisely the same function of the good or service substituted for; the substitute is the least-cost alternative; and evidence indicates an actual demand for the substitute.

Avoided damage costs

"The avoided damage cost method estimates the value of ecosystem services based on the costs of the damages that would occur due to the loss of these services." Similar to replacement cost, this method focuses on services that are lost if an ecosystem is not present or in poor enough condition such that the ecosystem services are not available. The avoided damage cost method is particularly useful for valuing services such as soil erosion and flood control, air filtration, and global climate regulation services.[50] The validity of the avoided damage cost method is dependent on two conditions:

- the avoided damages can be related to a specific ecosystem service.
- people would be willing to pay an amount to actually avoid the damage (i.e. this method is inappropriate if they are willing to just accept the damages).

Simulated exchange value

The simulated exchange value method estimates the price and quantity of an ES if it were traded in a hypothetical market. This is done using demand functions estimated using the travel cost or stated preference methods. Once demand functions are estimated, standard microeconomic methods are used to find the simulated price, and, in turn, the value of an ecosystem service. This method has not been as widely applied in research as other methods described above.

Value transfer

Value transfer, often called benefit transfer, isn't a valuation method in and of itself. Instead, it uses research results from existing studies for one location where data is available and applying it to a similar location where data is not. This method is commonly used when there is limited time or resources to conduct primary valuations.

TABLE 4

Overview of Research Estimating the Value of Wetlands' Net CO2eq. Exchange

Wetland Net Carbon Exchange

Source	Context	Notes on wetland(s) covered	Value (g CO2e m^{-2} $year^{-1}$)
Mitsch (2013)[51]	Ohio, U.S.	Planted created flow-through wetland	-760
Mitsch (2013)	Ohio, U.S.	Naturally colonizing created flow-through wetland	-807
Mitsch (2013)	Ohio, U.S.	Natural flow-through wetland	-316
Gallant et al. (2020)[52]	Nova Scotia	Average value across 55 wetlands that cover 5 types (fens, bogs, swamps, and both fresh and salt-water marshes)	-501.29
Li et al. (2020)[53]	Finland	Created urban stormwater wetland	263
Webster et al. (2018)[54]	Canada	Using Peatlands of Canada map	291,500,000
Webster et al. (2018)	Canada	Using newly created Canadian peatlands map	151,800,000

Note: positive values show net increase to atmospheric levels. These studies take the net effect of both carbon sequestered and methane released. Some values have been converted from C to CO2. We include estimates if they meet the following criteria: both methane leakage and carbon sequestration rates are examined; from a reputable source; published within the last 20 years; and are for wetlands in Canada or a similar geographic region.

CURRENCY CONVERSIONS

Values are converted to July 2023 Canadian Dollars using the PACIFIC Exchange Rate Service [55] (which relies on IMF data)[56] and the Bank of Canada's Inflation Calculator [57] (which relies on Consumer Price Index data from Statistics Canada)[58]. For sources that do not explicitly state the year and currency of results, assumptions were made based on context.

TABLE 5

Overview of Research Estimating the Value of Wetlands' Water Filtration

Wetland Water Filtration Value

Source	Wetland Type	Development Level	Context	Value ($ 2023 CAD/ha/year)
Aziz and Van Cappellen (2021)[59]	Fen	All	Southern Ontario	$3,477 *$2835 (CAD 2016)
	Swamp	All	Southern Ontario	$5,397 *$4400 (CAD 2016)
	Bog	All	Southern Ontario	$5,838 *$4760 (CAD 2016)
	Marsh	All	Southern Ontario	$8,297 *$6765 (CAD 2016)
Aziz and Van Cappellen (2021) referencing Wilson (2008)[60]	All	Mostly suburban and rural	Ontario's Lake Simcoe basin	$572 *$466 (CAD 2016)
Aziz and Van Cappellen (2021) referencing Anielski and Wilson (2009)[61]	All (freshwater)	Mostly rural	Canada's Boreal region	$554 *$452 (CAD 2016)
Aziz and Van Cappellen (2021) referencing Wilson (2008)	All	Mostly suburban	Greater Toronto Area 'Green Belt'	$694 *$566 (CAD 2016)
Wilson (2012)[62]	All	Mostly suburban and rural	Southern Ontario	$312–$922 *$236.99–$699.54 (CAD 2011)
Schuyt & Brander (2004)	All	Unspecified	World	$318 *$259 (CAD 2016)
Schmidt (2008)[63]	Natural permanent	Mostly rural	Southern Australia	$8,999–$16,097 *$7,100–$12,700 (assumed to be AUD 2007) **replacing half of filtration plant at 50% and 90% filtration efficiency compared with constructed wetlands)
	Natural permanent	Mostly rural	Southern Australia	$17,744–$31,940 *$14,000–$25,200 (assumed to be AUD 2007) **replacing whole filtration plant at 50% and 90% filtration efficiency compared with constructed wetlands)

Wetland Water Filtration Value

Source	Wetland Type	Development Level	Context	Value ($ 2023 CAD/ha/year)
Schmidt (2008)[64]	Natural temporal	Mostly rural	Southern Australia	$3,676–$6,717 *$2,900–$5,300 (assumed to be AUD 2007) **replacing filtration at 50% and 90% filtration efficiency compared with constructed wetlands)
Costanza et al. (1997)	All	Unspecified	World	$20,098 *$7977 (1994 USD) combined ($3800 water supply, $4177 waste treatment)
Costanza et al. (1997)	Tidal marsh / mangroves	Unspecified	World	$16,870 *$6696 (1994 USD) (waste treatment only)
Costanza et al. (1997)	Swamps / floodplains	Unspecified	World	$23,328 *$9259 (1994 USD) combined ($7600 water supply, $1659 waste treatment)
Troy & Bagstad (2009)[65]	Non-coastal	Non-urban	Southern Ontario	$3,794 *$2,779 (2008 CAD) (Water quality and waste regulation)
	All	Urban and suburban	Southern Ontario	$71,127 *$52,097 (2008 CAD) ($3,168 water quality / waste regulation $48,929 water supply/regulation)
	Great Lakes coastal	Unspecified	Southern Ontario	$3,632 *$2,660 (2008 CAD) (water quality / waste regulation)
Voigt et al. (2013)[66]	Great Lakes coastal	Unspecified	Ontario (in and around provincial parks)	$2,781 *$2111 (2011 CAD) (nutrient and waste regulation)
	Non-coastal	Non-urban	Ontario (in and around provincial parks)	$3,003 *$2279 (2011 CAD) (nutrient and waste regulation)
	All	Urban and suburban	Ontario (in and around provincial parks)	$46,993 *$35,668 (2011 CAD) ($3097 nutrient and waste regulation $32,571 water supply/regulation)
de Groot et al (2012)[67]	Coastal	Unspecified	World	$247,637 *$163,342 combined (2007 international currency) ($1,217 water provisioning) ($162,125 waste treatment)
	Inland	Unspecified	World	$13,689 *$9,029 combined (2007 international currency) ($408 water provisioning) ($5,606 regulation of water flows) ($3015 waste treatment)

Note: unless stated otherwise, values are in CAD 2023 and rounded to the nearest dollar.

WETLAND RESTORATION

Restoring wetlands can help regenerate natural ecological services in order to bring significant value back to a region. The two main methods for restoration are passive and active.[68] The passive approach involves removing the elements that previously caused loss or degradation, such as stopping farming activity, and allowing plants, wildlife and water to gradually return to the area. The active approach involves humans making physical changes to the land itself, including excavation and recontouring, removing invasive species, planting and seeding, and depositing new soil.[69]

The costs of restoration can vary widely depending on many factors, such as the size of the project, timing of the construction phase, construction techniques used, soil moisture conditions, the distance to an area to remove or relocate fill material, contractor availability, and vegetation fast-tracking preferences.[70] Moreno-Mateos (2015)[71] estimated that in a global context, restoration can range from $6177 (USD 2013) ($8,172.05 CAD 2023) per hectare for simpler projects to $160,618 (USD 2013) ($212,494.36 CAD 2023) per hectare for more complex endeavors. However, estimates from studies focusing on Canada are significantly lower. Lloyd-Smith et al. (2020)[72] compiled data from Boxall et al. (2009) [73] with a cost of $3,449.59 (CAD 2008) ($4,709.67 CAF 2023) per hectare for individual drained basins on agricultural land. Lloyd-Smith et al. (2020) also referred to Kanjilal (2015)[74] with ranges of $1,364.02–$2,416.69 (CAD 2019) ($1,574.10–$2,788.90 CAD 2023) per hectare in Saskatchewan and $1,398.62–$1,690.20 (CAD 2019) ($1,614.03–$1,950.52 CAD 2023) in Alberta, as well as Jeffrey et al. (2017)[75] with a range of $205.10–$237.22 (CAD 2019) ($236.69–$273.76 CAD 2023) per hectare in Alberta.

TABLE 6

Overview of Wetland Restoration Costs in Canadian and Global Contexts

Wetland Restoration Costs

Source	Context	Average Cost ($ 2023 CAD/ha/year)
Lloyd-Smith et al. (2020) referring to Boxall et al. (2009)	Manitoba (individual drained basins on agricultural land)	$4,710 *$3,449.59 (CAD 2008) **$1,396 per acre (CAD 2008)
Lloyd-Smith et al. (2020) referring to Kanjilal (2015)	Saskatchewan	$1,574–$2,789 *$1364.02–$2416.69 (CAD 2019) **$552–$978 per acre (CAD 2019)
Lloyd-Smith et al. (2020) referring to Kanjilal (2015)	Alberta	$1,614–$1,951 *$1398.62–$1690.20 (CAD 2019) **$566–$684 per acre (CAD 2019)
Lloyd-Smith et al. (2020) referring to Jeffrey et al. (2017)	Alberta	$237–$274 *$205.10–$237.22 (CAD 2019) **$83–$96 per acre (CAD 2019)
Asare et al. (2021)[76] referring to Hill et al. (2011)[77]	Saskatchewan (drained wetland in Assiniboine River Watershed)	$398 *$294 (assumed to be CAD 2010) **over 12 year contract)
Moreno-Mateos et al. (2015)	World (minor earthwork engineering to re-establish water flow)	$8,172 *$6177 (USD 2013)
Moreno-Mateos et al. (2015)	World (major earthworks including surface modification and extensive revegetation)	$212,494 *$160,618 (USD 2013)

Note: unless stated otherwise, values are in CAD 2023 and rounded to the nearest dollar.

Individual landowners can secure funding for wetland restoration through various sources, including governments, conservation authorities, environmental organizations and tax incentives.[78] Ducks Unlimited Canada provides partial funding for habitat projects that meet certain conservation goals if landowners sign a Conservation Agreement. This helps protect habitats while having limited interference on the owner's land use and enjoyment of their property. The organization can help with many aspects of the restoration project, including site suitability and biological assessments, permit assistance and additional funding sources.

There are a few characteristics that define a prime area for wetland restoration. It should have a significant water source (seasonal or permanent surface water or groundwater), hydric soils, flat or gently sloping topography, and poor or imperfect drainage.[79] Greater success in recovery can be seen in wetlands over 100 acres in area in warm or tropical climates that have significant hydrologic exchange.[80] Steep-graded land with coarse-textured soils that are close to roads or other human activity and could potentially impact neighbouring properties are much less suitable for restoration efforts.

To maximize the effectiveness of restoration, landowners and contractors should follow a set of project best practices. Variable water depths are key, with 25% to 50% of the wetland's area being 1 meter or more with a maximum depth limit of 1.5 meters overall.[81] Side slope gradients of 10:1 — 15:1 are best, and sediment capture trenches that can be cleaned out with machinery and are no more than 2.5 meters deep should be implemented. Vegetated area should cover 25% to 50% of the wetland's surface area, with some submerged vegetated benches set at 0.3 meters below the anticipated average water level.

The positive effects of wetland restoration can be significant in terms of ecological services. Meli et al. (2014)[82] reported that "restored wetlands showed 36% higher levels of provisioning, regulating and supporting ES than degraded wetlands." Additionally, restored wetlands "showed levels of provisioning and cultural ES similar to those of natural wetlands."

However, restored wetlands do not always create anywhere close to the same positive impact as naturally occurring, unaltered ones. Moreno-Mateos et al. (2012)[83] found that "on average, restored wetlands are 25 percent less productive than natural wetlands" even a century after initial intervention.[84] Meli et al. (2014) asserted that supporting ecosystem services were 16% lower in restored wetlands and regulating ecosystem services were 22% lower in restored wetlands. A Kotze et al. (2018)[85] study from South Africa found that "for most (77%) of the wetland units, restoration contributed to a modest 10–30% improvement in ecological condition."

The changes seen from restoration are usually graduate in nature. Moreno-Mateos (2018)[86] said that "during the long period in which wetlands are recovering their biodiversity and functions, their positive effects on other ecosystems and their provision of ecosystem services are diminished." An earlier study from Moreno-Mateos and others in 2012 clearly articulated that "current restoration practice fails to recover original levels of wetland ecosystem functions, even after many decades." It found that wetland carbon storage capacity only recovered 50% after 20 years[87]. Another article from Ballantine and Schneider (2009)[88] examining wetlands in central New York State stated that soil organic matter in the top 5cm, critical to the ecosystem's functioning, only recovered by 50% compared to reference levels after 55 years.

Fully restoring a wetland can take a significant amount of time. A study conducted by Pezzati et al. (2018)[89] found that the most common recovery times for actively restored wetlands were less than 1 year (38%), 1–10 years (24%) and 10–100 years (26%). However, 4% could take 100–1000 years, 3% could take 1,000–10,000 years, and another 4% could take 10,000 or more years. Longer recovery times were much more common for passive restoration, with 30% recovering in 100–1000 years, 25% recovering in 1,000–10,000 years, and 27% recovering in 10,000 or more years. Only 0.25% of passively restored wetlands fully recovered in less than 1 year, with 5% taking 1–10 years and 13% taking 10–100 years.

ENDNOTES

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2 Source: Economic Research Service, U.S. Dept. of Agriculture, Heimlich et al. "Wetlands and Agriculture: Private Interests and Public Benefits," 1998.

3 Source: Global Environment Change, Robert Costanza et al. "Changes in the global value of ecosystem services," 2014.

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5 Source: Statistics Canada. "Canadian System of Environmental-Economic Accounts — Ecosystem Accounts," 2023.

6 Source: NCAVES and MAIA collectively known as SEEA (2022). "Monetary valuation of ecosystem services and assets for ecosystem accounting: Interim Version 1st edition." United Nations Department of Economic and Social Affairs, Statistics Division, New York.

7 Source: *Nature*, vol. 387, 253-260. Robert Costanza, et al. "The value of the world's ecosystem services and natural capital," 1997. Note: The updated Costanza estimates only provide overall wetland value and don't specify for water filtration by itself.

8 Source: Sustainable Development Branch, Canadian Wildlife Service, Conservation and Protection, Environment Canada, National Wetlands Working Group Canada Committee on Ecological Land Classification. "Wetlands of Canada," 1988.

9 Note: To produce Table 10-15 the quoted report gathered, from multiple papers, estimates on wetland economic values for Canada by sector and source. The most valuable grouping was "non-consumptive recreational photography, bird-watching, guiding, travel, education," followed by flood peak modification, water purification, recreational consumptive sport fishing, and peatland forestry (list is non-exhaustive). The report highlights that water purification and flood peak modification are "fixed, non-annual values." We were not able to access the original source of these estimates that are from 1985 and 1981, meaning we couldn't read why they were classified as fixed values.

10 Source: Natural Capital Project, Stanford University. "Gretchen Daily," no date.

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12 Source: Global Environment Change, Robert Costanza et al. "Changes in the global value of ecosystem services," 2014.

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15 We excluded studies which were based in areas with significantly different climates to Canada's (e.g., subtropical wetlands). Estimates used must have both methane and carbon sequestration rates. Finally estimates must be presented in a way that allows for the use of a standardized metric (tonnes of CO2eq. per year per hectare).

16 The SEEA recommends using a country's existing market. For countries without these markets they recommend using prices from the Clean Development Mechanism. Canada does not have a country-wide mature emissions trading scheme. Further, the prices found in Clean Development Mechanism scheme tumbled into a 'carbon panic', falling to just 0.5 euro per tonne in CO2 in 2012 and the pricing mechanism broke down completely. Source: Centre for Economic Policy Research, Kazunari Kainou. "Collapse of the Clean Development Mechanism scheme under the Kyoto Protocol and its spillover: Consequences of 'carbon panic,'" 2022. Lastly, the SEEA also mentions the abatement cost estimate method but states several drawbacks and ultimately does not recommend it for accounting purposes.

17 We excluded studies which were based in areas with significantly different climates to Canada's (e.g., subtropical wetlands). Estimates used must have both methane and carbon sequestration rates. Finally, estimates must be presented in a way that allows for the use of a standardized metric (tonnes of CO2eq. per year per hectare).

18 Source: United Nations. "System of Environmental Economic Accounting," 2012.

19 The social cost of carbon (SCC) is also often called the damage costs of emitting carbon. The SEEA states these "values are based on the discounted costs arising from adding one ton of CO2 over the long term and are sensitive to the discount rate adopted."

20 Source: Environment and Climate Change Canada. "Social cost of greenhouse gas emissions," 2023.

21 Source: World Wildlife Fund, Kirsten Schuyt & Luke Brander. (2004). "Living Waters, The Economic Values of the World's Wetlands," 2004.

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43 Source: Taskforce on Nature-related Financial Disclosures. "About," no date.

44 Source: Government of Canada, Revised Statutes of Canada. "Canada Wildlife Act (R.S.C., 1985, c. W-9)," 2017.

45 Source: Government of Canada. "Wildlife Area Regulations (C.R.C., c. 1609) Canada Wildlife Act," 2023.

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