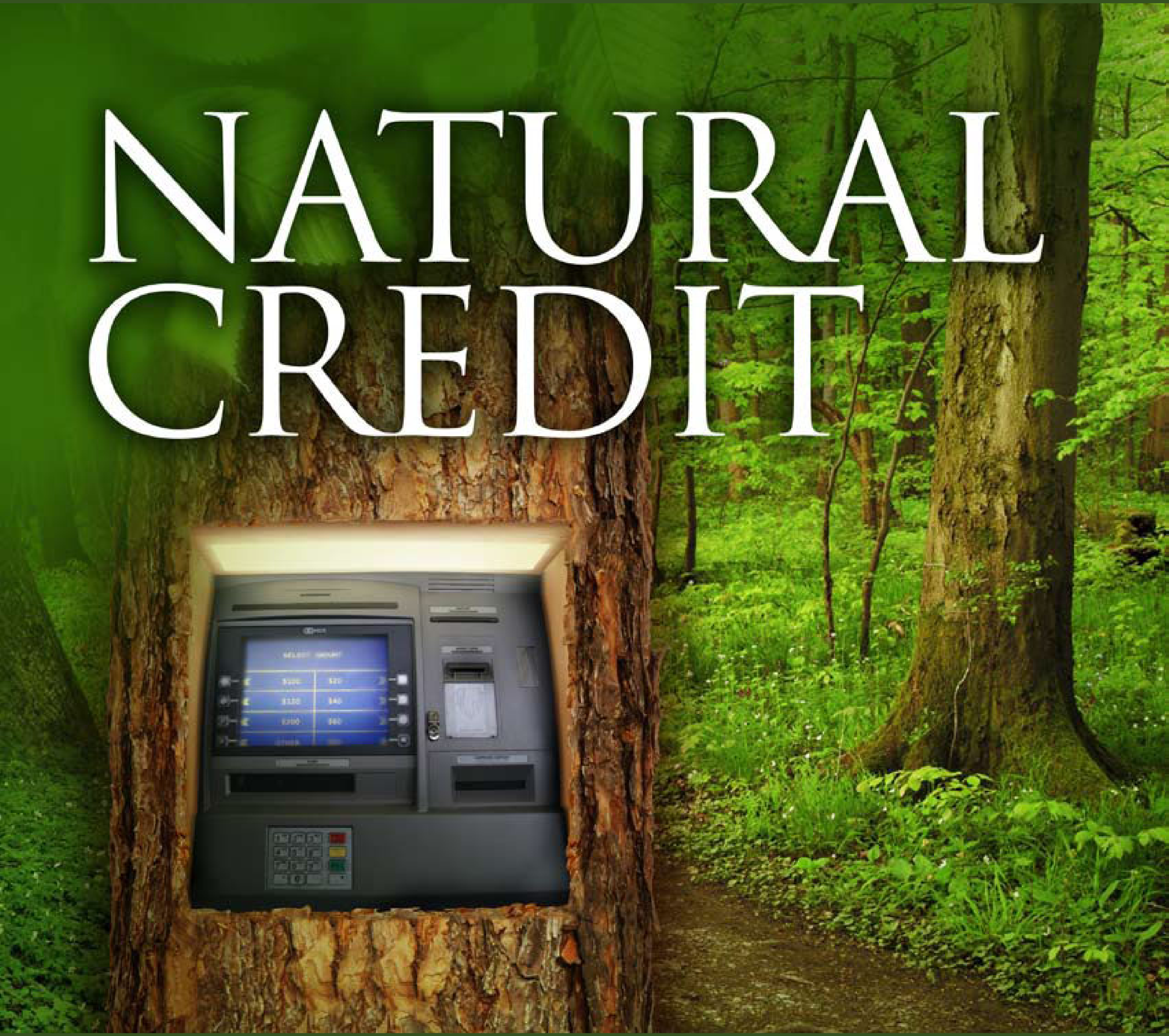
NATURAL CREDIT



Estimating the Value of Natural Capital in the Credit River Watershed

Mike Kennedy • Jeff Wilson

November 2009

CVC
CREDIT VALLEY CONSERVATION

the PEMBINA institute
Sustainable Energy Solutions

Natural Credit

Estimating the Value of Natural Capital in the Credit River Watershed

Mike Kennedy

Jeff Wilson

November 2009

Natural Credit: Estimating the Value of Natural Capital in the Credit River Watershed
November 2009

Editing and Layout: Roland Lines
Cover Design: Rob Weidemann

ISBN 1-897390-19-X

The Pembina Institute
Box 7558
Drayton Valley, Alberta
Canada T7A 1S7
Phone: 780-542-6272
Fax: 780-542-6464
Email: info@pembina.org

Credit Valley Conservation
1255 Old Derry Road
Mississauga, Ontario
Canada L5N 6R4
Phone: 905-670-1615 or 1-800-668-5557
Fax: 905-670-2210
Email: cvc@creditvalleyca.ca

Additional copies of this publication may be downloaded from the websites of the Pembina Institute (www.pembina.org) and Credit Valley Conservation (www.creditvalleyca.ca).

About the Pembina Institute

The Pembina Institute is a national non-profit think tank that advances sustainable energy solutions through research, education, consulting and advocacy. It promotes environmental, social and economic sustainability in the public interest by developing practical solutions for communities, individuals, governments and businesses. The Pembina Institute provides policy research leadership and education on climate change, energy issues, green economics, energy efficiency and conservation, renewable energy, and environmental governance. For more information about the Pembina Institute, visit www.pembina.org or contact info@pembina.org.

About the Credit Valley Conservation

Credit Valley Conservation (CVC) was formed on May 13, 1954, and has been working for over 50 years to protect the natural environment. CVC is one of 36 conservation authorities operating in Ontario and is a partnership of the municipalities within the Credit River Watershed. CVC is a community-based environmental organization originally formed by an Act of provincial government and dedicated to conserving, restoring, developing and managing natural resources on a watershed basis. More information about CVC is available at www.creditvalleyca.ca.

About the Authors

Mike Kennedy, M.Sc., is a Senior Resource Economist with the Pembina Institute's Green Economics and Policy program. Mike's research work involves providing policy advice to government, private corporations and other non-government organizations in Canada and abroad on policy issues related to natural resource valuation, ecological goods and service provision, carbon pricing, and tax policy for natural resource sectors. Mike holds a Master of Science, with a concentration in natural resource and environmental economics, from the University of New Brunswick.

Jeff Wilson, M.Sc., is a project coordinator with Credit Valley Conservation (CVC), where he guides and manages CVC's research initiatives relating to ecological goods and services. His areas of expertise include valuing ecological goods and services, non-market valuation techniques, and cost-benefit analysis. Jeff holds a Bachelors of Arts in economics and finance from Wilfrid Laurier University and a Master of Science, with a concentration in environmental economics, from the University of New Brunswick.

Acknowledgements

The authors would like to thank Sara Wilson (Natural Capital Research and Consulting), Nancy Olewiler (Simon Fraser University) and Van Lantz (University of New Brunswick), who provided thoughts, ideas and review for this work.

We would also like to thank various employees of Credit Valley Conservation who assisted in data collection, processing and commenting on drafts, including Mike Puddister, Brian Morber, Dan Schuurman, Heather Yates, Jamie Ferguson, Aviva Patel, Pauline Quesnelle, Zoltan Kovacs, Brian Boyd, Victoria Maines, Tyler Babony, John Kinkead, Rae Horst and Christine Zimmer.

Any errors and omissions in this report are those of the authors, for which we take complete responsibility.

Natural Credit

Estimating the Value of Natural Capital in the Credit River Watershed

Contents

List of Tables

List of Figures

Foreword

Since 1954, Credit Valley Conservation has been active in the management, protection and restoration of the Credit River Watershed's natural features and functions. Our vision is for "an environmentally healthy Credit River Watershed for present and future generations." We also have as one of our goals "to promote social and economic health of the community through effective watershed management."

We have developed leading-edge approaches to tracking the health of this system over time through our Integrated Watershed Monitoring Program, and we carry out studies at watershed and subwatershed scales. However, the recent updates to our Water Management Strategy, combined with other initiatives locally, regionally and globally, have made it clear that this is not enough. While progress is being made, significant changes in the way we relate to the watershed and its natural systems are required. The case for conservation must be based not only on ecological grounds, but also on the basis of what it means for the well-being of the community: the people who live, work and recreate within the watershed.

This project has gone beyond the role typically played by a conservation authority in promoting the importance of a watershed's natural features and functions as it investigates the human benefits of watershed protection and restoration. This work is an initial step to address the deficiency of such information and the growing need for social and economic perspectives in watershed management. The concepts of natural capital and ecological services provide a basis for better understanding how people benefit from a healthy watershed today and through effective management can continue to benefit in the future.

The reality is no one makes decisions with the intent to do harm. Land-use changes are, however, driven by economic growth and the need to meet increased demands for housing, food and other consumer goods and services, all of which provide a better quality of life. External costs imposed by these activities are simply not accounted for and are ultimately borne by society. Continuing to ignore these costs in our quest for a better quality of life could end up undermining the very source of our well-being and life supporting ecosystems, and may actually cost us our quality of life.

The underlying message in this report is that a fundamentally new approach to protecting and growing natural capital is needed. A paradigm shift that recognizes the natural systems that make up the watershed are not simply resources to be extracted, but represent elements of an ecosystem upon which we all depend. It provides our life and economic support systems.

Mike Puddister
Director, Restoration and Stewardship
Credit Valley Conservation

Note from the Authors

When we set out to conduct this research, our primary objective was to make an initial coarse assessment of natural capital and ecological services in the highly urbanized Credit River Watershed. The intention was to educate and build awareness of the fact that ecological services provide significant value that should not be dismissed when making land-use decisions. Recognizing the value of natural capital is the first step towards incorporating it into future decision-making. Our analysis is also intended to encourage dialogue among local stakeholders regarding the need for full cost accounting in the future.

The method and process we used to apply values to the Credit River Watershed admittedly have inherent weaknesses, and as a result are not appropriate for specific land-use decision-making. However, our objective to communicate the importance of natural features to human well-being in the watershed meant that the precision of estimates was not overly critical. To carry out a watershed-specific valuation of the numerous services provided would be extremely costly and time consuming. Thus, due to resource constraints we elected to take a more cost-effective approach, sacrificing precision.

Furthermore, while we argue that the value of ecological services can and should be used in making future policy or land-use change decisions, the reality is that much more detailed information about people's preferences, alternative infrastructure and policy options would be required to properly account for the trade-offs associated with any given policy.

The concepts presented in this report are increasingly emerging in policy and resource management in many jurisdictions across the globe, however considerable effort and resources are needed to adequately develop the valuations needed to properly assess trade-offs and make sound decisions on resource use. It is our hope that this study will lay the foundation and begin building the institutional knowledge necessary to consider the full costs of policy and land-use changes within the Credit River Watershed and beyond.

Regards,

Mike Kennedy	Jeff Wilson

Executive Summary

Natural Credit: Estimating the Value of Natural Capital in the Credit River Watershed

The Credit River Watershed provides a minimum of $371 million in ecological services annually to area residents

Without nature, humans could not survive. Nature provides the raw materials for every product we consume. More importantly, it constantly supplies services that sustain life, such as fresh drinking water, food and clean air. Nature directly affects human wellbeing by meeting a wide variety of human needs, whether from tangible ecological services or from more abstract connections to nature.

Unfortunately, current accounting systems rarely, if ever, account for nature. In fact, we often assume nature provides unlimited resources. We act as if the bank of nature has unlimited resources, and we keep making withdrawals as if there is no tomorrow.

By accounting for natural capital we can start to align our economic ambitions with our ethical environmental responsibility — to provide future generations with at least the same benefits from nature that we enjoy.

The Pembina Institute worked with Credit Valley Conservation (CVC) to assess the value of natural capital in the Credit River Watershed. This work is an important component of the information CVC needs to effectively manage the ecological resources in the watershed. Given its proximity to major urban centres (Toronto and Mississauga), the Credit River Watershed faces threats to its natural heritage from resource use and land-use change.

The benefits transfer approach

To value the natural capital in the Credit River Watershed we used a benefit transfer approach to estimate the flow of benefits from ecological services provided by the watershed. Benefit transfer relies on studies done in other regions. By transferring and adjusting monetary values for similar ecological services from other regions we can approximate the values in the Credit River Watershed. Some of the values come from other regions in Ontario, Saskatchewan, New York, Massachusetts and Europe.

Natural capital saves watershed tax-payers $100 million of water supply costs every year

Natural capital builds on the notion that Mother Nature does for free what we would otherwise have to pay millions of dollars to do through technology and infrastructure. When we allow growth, pollution or other impacts to compromise these valuable services, that lost value is ultimately borne by taxpayers. The way we do business today, those costs are not accounted for.

This study helps demonstrate that it is possible to come up with real numbers that can inform discussions about land use and development. For example, this study estimates that if we compromise our groundwater supply it would cost more than $100 million per year to pump water from Lake Ontario. And that is just to maintain current water use.

Wetlands are worth a minimum of $187 million annually to the residents of the Credit River Watershed.

Based on this partial assessment, the natural capital of the Credit River Watershed delivers a constant flow of services to society of at least $371 million per year.

- Wetland services were found to be the most valuable in the watershed, returning an annual flow of benefits worth a minimum of $187 million per year.
- The current mix of forests in the watershed, composed of upland forests, riparian forests and urban forests, return at least $71 million per year, $51 million per year and $19 million per year, respectively.
- Water benefits in the Credit River Watershed are greater than $15 million annually.

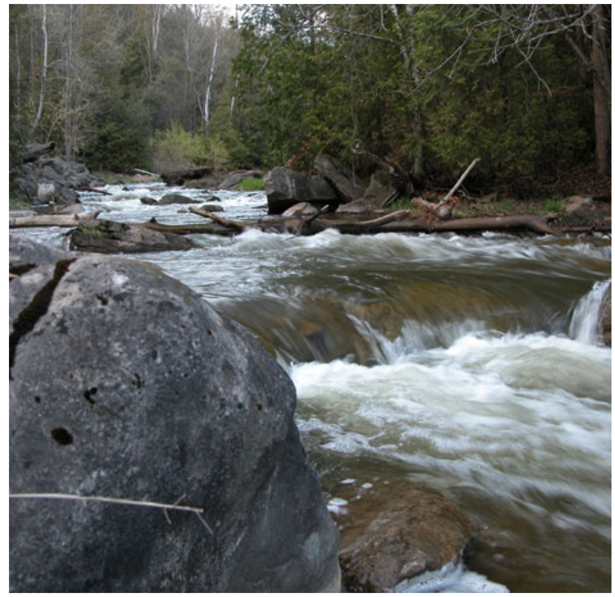
How changes in land cover affect the flow of nature's services

The natural capital of the Credit River Watershed is extremely valuable. To test the impacts of land-use decisions we examined two scenarios: urban development and reforestation and naturalization.

Urban Development: Based on a recent CVC study of future urban development, this scenario increased the urban land cover from 15% to 25% of the watershed, while using current best management practices.

Reforestation and Naturalization: Based on CVC's 10-year capital plan, which set massive reforestation and naturalization goals as part of a climate change strategy, this scenario includes planting 2.5 million seedlings and 317,000 trees and shrubs.

As urban development proceeds there is a real cost to natural capital and a risk that higher value land cover types could be jeopardized. An approach like the one used in this study can help measure the costs of urban development and the economic benefits of conservation initiatives such as reforestation and naturalization. Further, this type of work can turn the balance sheets around on how businesses and governments approach nature. Based on the analysis done in this report, if CVC invests the $8 million over 10 years to plant trees and shrubs on abandoned and degraded lands, the return to society is over $13 million per year.



Natural capital consists of the assets of natural ecosystems whose very presence yields a flow of ecological services.

There are a number of potential development patterns that could emerge in the Credit River Watershed. If urban development progresses under business as usual from 15% urbanization today to 25% urbanization, we can expect losses to natural capital of more than $31 million per year.

Recommendations

CVC saw the need to better understand the economic value of nature's services. The issues faced in the Credit River Watershed are not uncommon to many other regions in Canada. The authors recommend that governments at the federal, provincial and municipal level consider making natural capital and its maintenance a higher priority in future planning. Further, we recommend strong leadership through four areas of improvement:

1. **Investments in a robust framework for natural capital accounting**
2. **Investments in natural capital**
3. **Investments in further education and awareness**
4. **Incentives for the conservation of ecological services**

Glossary of Terms

Benefit transfer: The benefit estimated for one or more sites or policy proposals is used to assign benefit or value to other, comparable sites or policy proposals.

Contingent valuation: A survey-based technique that uses survey participants' stated-preferences to establish values for ecological services and/or changes in ecosystem conditions.

Cost-benefit analysis: A tool for comparing the benefit to society and/or government with the costs to society and/or government for making a particular policy or management decision.

Ecological services: The goods and services provided by ecosystems and their functions (often used interchangeably with environmental services or ecosystem services).

Full-cost accounting: The process of collecting and presenting a complete set of economic, social and environmental costs and benefits for proposed alternatives when a decision is necessary.

Marginal benefit: The change in total benefit as a result of protecting or restoring one more unit of a particular good or service.

Marginal cost: The change in total cost as a result of consuming, depleting or damaging one more unit of a particular good or service.

Natural capital: The stock of resource and environmental assets, including the flows of ecological services, that exist in a region at a given point in time.

Total economic value: The sum of all values derived from the use or existence of a good or service.

Natural capital valuation: The process of assigning value to the market and non-market goods and services provided by ecological systems.

Willingness to accept: A monetary measure of the minimum amount an individual would accept to forgo a positive change in the quantity or quality of a good or service or agree to a negative change in the quantity or quality of a good or services.

Willingness to pay: A monetary measure of the maximum amount an individual would pay to obtain a positive change in the quantity or quality of a good or service or avoid a negative change in the quantity or quality of a good or service.

1. Introduction

Without nature humans could not survive. It provides the raw materials for every product we consume, and more importantly a constant supply of services that sustain life, such as fresh drinking water. Nature is directly tied to human well-being through its ability to provide a wide variety of human needs, from the tangible services, such as raw materials, to much more abstract needs, such as our psychological connections to nature.

The services nature provides are tremendously valuable to humans. Unfortunately, because these services are rarely, if ever, accounted for in commercial markets their value often goes unnoticed by decision makers. When this happens these ecological services are unintentionally assumed to be worthless.

This report begins to address this issue by articulating the connection between nature and human well-being in such a way that decision makers and the general public recognize the magnitude of the natural capital value and make more informed decisions.

1.1 The Importance of Accounting for Natural Capital

Recently, increased awareness of the imminent global threats of climate change has spurred policymakers and corporations into action to deal with increased atmospheric concentrations of carbon dioxide. The failure to incorporate the cost borne by society from the harmful effects of climate change is but one example where a reliance on traditional economic thinking has proven inadequate and has resulted in a need to overcome what economics refers to as market failure.

Increasingly, signs are emerging that we are living beyond the ability of the planet to sustain economic growth. Indeed, we are currently conducting trade-offs between environmental quality and economic growth in ways that are not in line with Canada's global[1] and domestic commitments to promote and enact sustainable development.

The good news is that the environment is a wonderfully resilient system that, when managed properly, can maintain and even enhance our overall well-being. To protect the potential of the natural environment for present and future generations we need to better account for the value of ecological services in decision-making processes. These services are currently free of charge. The typical approach ignores the non-market value of ecological services, forcing decision-makers to make decisions about land-use allocations that often lead to society bearing more costs than benefits. If we wish to make decisions that improve the overall human well-being of society then we must systematically account for natural capital. Given that decision-making is dominantly informed by economic rationality we must be able to compare policy options that

[1] Canada has committed to a number of global agreements, conventions and protocols aimed at pursuing objectives related to sustainable development, including the Johannesburg Declaration, Agenda 21, Convention on Biological Diversity, Rio Declaration on Environment and Development, Forest Principles, Montreal Protocol, Kyoto Protocol, and Millennium Development Goals. For more information, see www.sdinfo.gc.ca/s15_e.cfm.

include the intangible costs and present them in economic terms. Not doing so will always lead to an inefficient allocation of resources.

Further undermining sustainable decision-making (at the household and government level) is our approach to the use of raw materials. Since the Industrial Revolution the cost of raw materials, as inputs into production processes, has often been lower then the true economic cost of primary resource use (mining, oil and gas, forestry, farming, etc.), due to the absence of consideration for external pollution costs.[2] Much of the unsustainable business practices in Canada can be traced to the lack of clear economic signals (incentives and disincentives) that serve to direct investment and operational decisions. By accounting for ecological services and incorporating this economic value into decision-making we can direct our economy towards an environmentally sustainable future.

1.2 Ecological Services and the Credit River Watershed

The Pembina Institute was commissioned to work with Credit Valley Conservation (CVC) to assess the value of natural capital in the Credit River Watershed. Given the proximity to major urban centres (Toronto and Mississauga), the Credit River Watershed is under threat from land-use change. This work is considered to be an important component of the information CVC needs to effectively manage the ecological resources in the watershed.

The Credit River Watershed (Figure 1) is an important sub-component of the Great Lakes Basin and is home to roughly 750,000 people. The Credit River flows from its origins north of the Town of Orangeville to Lake Ontario at Port Credit in the City of Mississauga. Typical of other regions in southern Ontario, the Credit River Watershed has a growing urban population, which creates outward development pressure into what were once rural areas in order to meet demands for housing, recreation, food and material production, clean water, clean air, and waste treatment.

The natural features and functions of this ecosystem contribute significantly to human well-being through a number of different ecological services. Clean air, clean water, the assimilation of waste, the regulation of climate and of water flows, food, wildlife habitat, recreation, and spiritual opportunities are all provided to society by a healthy and functioning ecosystem. In the case of clean water, the watershed provides drinking water for residents of the northern portions of the watershed and contributes to the quality of water in Lake Ontario (the source of drinking water for the balance of the watershed's population). The composition of this landscape is vital to maintain the suite of ecological services that helps sustain quality of life in the region.

1.3 Significance of Ecological Services

Sometimes the provision of ecological services is afforded to society at a very low cost, and often at no cost at all. It is important to ensure that these functions can continue to exist without being harmed or impaired by irresponsible land-use practices. When a healthy and functioning ecosystem does not exist, society is required to substitute the goods and services those ecosystems provide. In some cases the substitution of natural infrastructure can be done through

---

[2] John Young and Aaron Sachs, "The Next Efficiency Revolution: Creating a Sustainable Materials Economy," World Watch Paper 121 (Washington, D.C.: World Watch Institute, 1994).

the design and construction of elaborate management systems. In other cases, substitutes for some ecological services do not exist. When substitution is possible, it generally comes at a greater cost than would have incurred to maintain the functioning ecosystem. When substitutes do not exist, losing ecological services is far more serious.

One example that typifies the cost-effectiveness of nature's ability to provide services is in the Catskill Watershed, the source of drinking water for New York City. It was determined that building a water filtration plant would cost a great deal more for New Yorkers than investing in the protection and restoration of natural forest and wetland cover that performs a water-filtration service for watershed residents (see text box). New York's clean drinking water is just one example of how nature is better suited to provide society with the critical services needed to survive. Many examples exist in other jurisdictions, such as Costa Rica, Australia, Ottawa, Prince Edward Island, Guatemala, California, among others, where human made substitutes have proven to be more costly than nature's ability to sufficiently and efficiently address a particular environmental issue.[3]

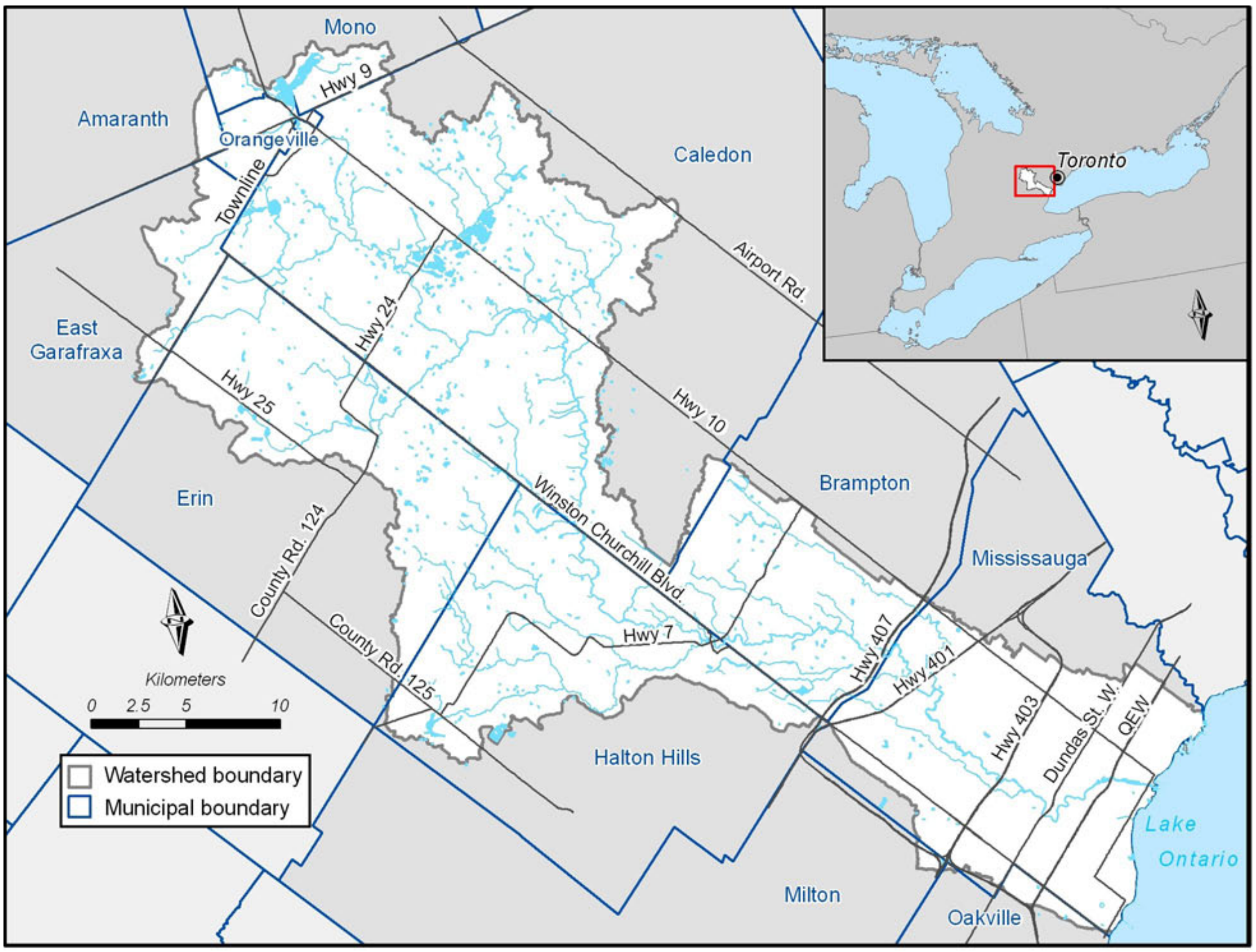


Figure 1. Map of Credit River Watershed

Source: Credit Valley Conservation 2008

[3] Forest Trends and the Ecosystem Marketplace, *Payments for Ecosystem Services: Market Profiles* (Washington, D.C.: 2008), ecosystemmarketplace.com/documents/cms_documents/PES_Matrix_Profiles_PROFOR.pdf.

Nature's Economic Efficiency: New York City Drinking Water[4]

The watersheds that feed the Catskill Escarpment have traditionally supplied high-quality drinking water to the City of New York. Over the past half century, increased pressure from development and agriculture, and run-off from roads, has posed threats to the water quality in the region. To meet the U.S. Environmental Protection Agency's enhanced requirements for water quality, in 1989 New York City would have had to invest $2 to $6 billion to construct, and $300 million annually to operate, a new water treatment plant.[1] Recognizing that the existing Catskill Escarpment could provide the equivalent service as a capital-intensive water filtration plant, the city assessed the value of the Catskill ecosystem to meet the water filtration needs of the city. The cost for protection and restoration for the watershed was found to be significantly less than the cost of the new water treatment plant. In fact, for a cost of between $1 and $1.5 billion, the city found that it would be able to adequately restore the ecological service of the watershed to a level sufficient to ensure appropriate water filtration.

Once the cost of restoration activities was assessed to be sufficiently lower than the cost of the water treatment facility, the City, the U.S. Environmental Protection Agency, five environmental groups and local agriculture organizations worked together to establish a water management strategy that would ensure sufficient protection of the escarpment and hence drinking water quality. The strategy included a payment for ecosystem service program, through which payments were made available to landowners within the escarpment for enhanced land protection. Once implemented, the city of New York was able to successfully protect the Catskill Escarpment and avoid the need for considerable capital and operational expenditures.

1.4 Purpose of the Report

The purpose of this report is to conduct an initial baseline estimate of the flow of benefits provided to residents of the Credit River Watershed from the existing stock of natural capital in the region. Further, this report assesses the changing flow of benefits from natural capital through a scenario analysis to provide insight into how future land-use trends in the watershed affect natural capital estimates. More specifically, this report has the following objectives:

- to educate and build awareness of natural capital and ecological service values in the watershed
- to demonstrate the importance of considering changes in natural capital and ecological service values when making land-use decisions in the watershed

1.5 Outline of the Report

This report is organized into six sections, including the introduction. Each chapter in this report will touch on a variety of elements related to the objective, which is to quantify an estimate of the value of natural capital in the Credit River Watershed. The subsequent sections include:

Chapter 2: The Credit River Watershed

In this section we introduce the Credit River Watershed, define its context, outline the current land uses and highlight the main threats to natural capital.

[4] Rutherford H. Platt, Paul K. Barten and Max J. Pfeffer, "A Full, Clean Glass?" *Environment* 42, no. 5 (2000).

Chapter 3: Study Approach

To conduct this analysis we used a natural capital valuation method called benefits transfer. In this section we introduce the approach to natural capital valuation used and outline how we conducted the analysis. Given the fact that this topic is fairly new in its practical application, we also provide a specific example of how we applied this approach to a particular ecological service for a particular land cover type.

Chapter 4: Value of Natural Capital in the Credit River Watershed

This section includes the results and findings of the analysis, demonstrating the value of natural capital in the watershed.

Chapter 5: Scenario Analysis

This section defines two land-use change scenarios and explores how the concept of natural capital could be used to inform decision makers of affects of land-use change on ecological services.

Chapter 6: Discussion and Conclusions

This section contains a summary of the study findings and a context for how natural capital values might be used in decision-making.

2. The Credit River Watershed

A watershed is often defined as the land and water drained by a river and its tributaries. Watersheds represent an ecosystem unit within which physical, biological and cultural features are connected by a complex network of ecological functions and linkages, influenced by natural processes and human activities.[5] The watershed of concern in this report is the Credit River Watershed, which is under the jurisdiction of the Credit Valley Conservation Authority.

2.1 Geographic Context of the Credit River Watershed

The Credit River Watershed is located in one of the most densely populated regions of Canada, the Greater Toronto Area. The Credit River and roughly 1,500 km of its tributaries drain nearly 1,000 km^2 of land. The watershed has three relatively distinct physical regions, which are referred to as the upper, middle and lower watershed, characterized by the spatial distribution of land features (Figure 2).

The *upper watershed*, which lies above the Niagara Escarpment, is characterized by till plains, hummocky moraines and glacial spillways. The highly permeable soils and hilly topography of this region lead to significant rates of groundwater recharge, supplying water to the regional groundwater aquifers, which are the source of domestic water consumption for most of the residents in this rural portion of the watershed. The flow of the river and its tributaries are largely maintained by groundwater discharge. Dominant vegetation cover includes sugar maple forests and white cedar swamps. Traditionally, agriculture has been the main land use in the area, but in recent years the land use has been shifting to rural estate development.

The *middle watershed* includes the Niagara Escarpment and is dominated by steep slopes, significant rock outcrops and thin soil conditions. Slopes in this region are steep, and in some areas sharp cliff faces dominate the landscape. Such topography leads to high volumes and velocities of runoff, with the Credit River flowing through a steep-walled, narrow valley. The Oak Ridges Moraine is a central feature of the eastern portion of this region. The Escarpment plateau is heavily forested with a mixture of deciduous stands in upland areas and coniferous swamps in lowland areas. Land use along the Escarpment is strictly regulated by the Niagara Escarpment Commission. There are numerous recreational areas, and the Bruce Trail runs through the zone along the edge of the Escarpment.

[5] CVC, *Credit River Water Management Strategy Update* (Mississauga, ON: Credit Valley Conservation, 2007).

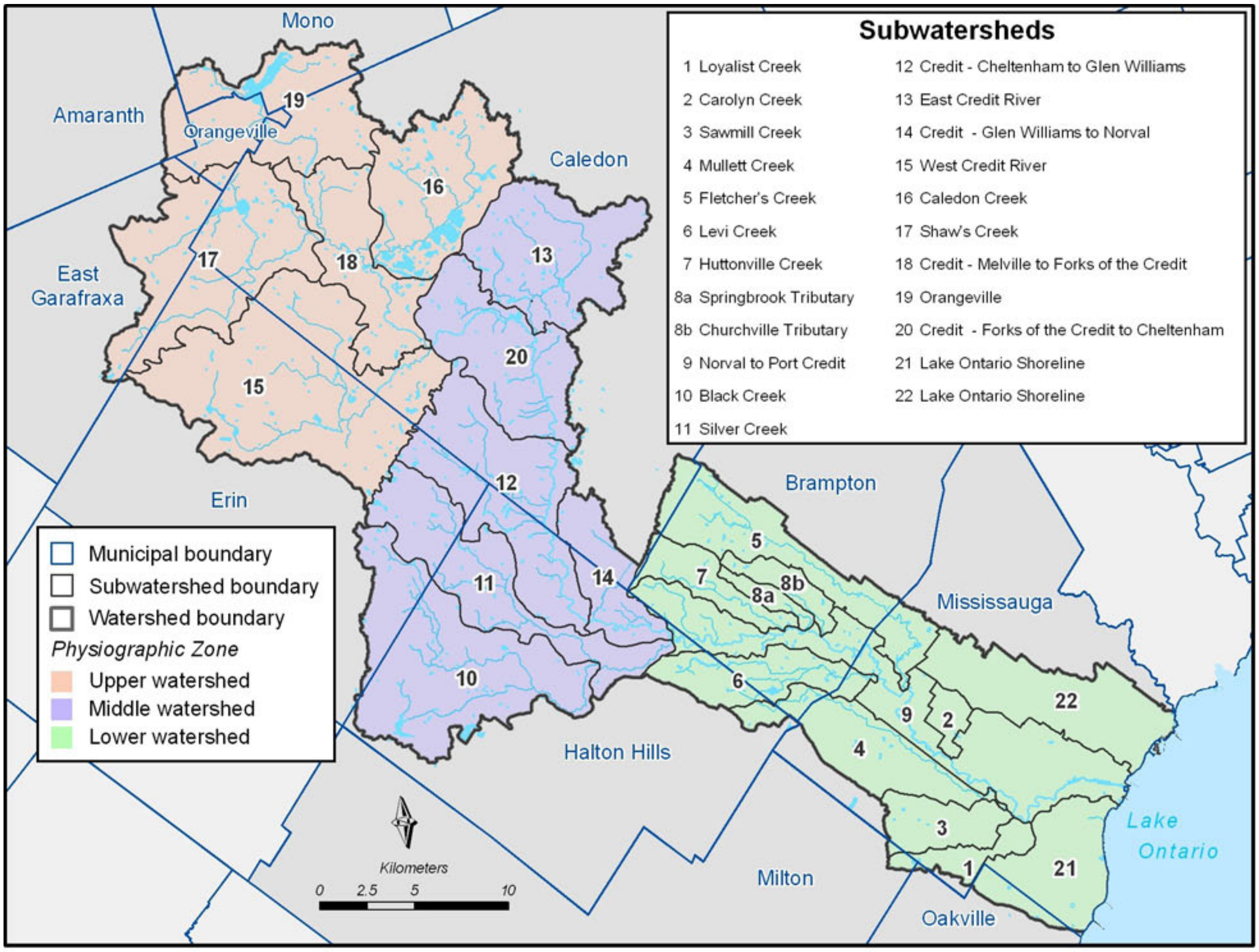


Figure 2. The Credit River Watershed and subwatersheds

Source: Credit Valley Conservation 2008

The *lower watershed* is characterized by a relatively flat surface topography with a gentle southward slope towards Lake Ontario. The soils typically have low rates of infiltration compared to other regions, leading to higher rates of runoff. As a result of urban development in this portion of the watershed, many of the tributaries have been channelized or enclosed. The lower watershed is highly urbanized, with over 80% of the watershed population residing in this region. Population densities range from 500 to more than 1,000 people per square kilometre.[6] This region encompasses most of Mississauga and the western portion of Brampton. The large majority of residents in this area of the watershed obtain their drinking water from Lake Ontario.

To help guide the management of the Credit River Watershed, it was divided into 20 subwatersheds. As shown in Figure 2, subwatersheds 1 through 20 drain into Lake Ontario via the Credit River, delineating the actual watershed boundary. However, within CVC's jurisdiction are two other management areas (numbers 21 and 22 in the map), which consist of a series of small distinct basins draining directly into Lake Ontario.

[6] CVC, *Credit River Water Management Strategy Update.* (Mississauga, ON: Credit Valley Conservation, 2007).

2.2 Land Use in the Credit River Watershed

Because the Credit River Watershed is situated within the Greater Toronto Area, its land use is significantly influenced by regional economic forces, namely land costs and proximity to Toronto. Increasing land costs in Toronto, coupled with historically low fuel costs, has encouraged people to move out of Toronto and into neighbouring municipalities, such as Brampton and Mississauga. In addition, many companies have chosen to set up operations outside Toronto to take advantage of lower property costs while maintaining relative proximity to the economic hub of Toronto. Consequently, the watershed's proximity to Toronto and regional differences in property costs have driven urban development pressures in the Credit River Watershed.

The urbanized lower portion of the watershed has also affected the rural landscape. With more high-income households in the region, there is a greater demand for rural estate properties, hobby farms and horse farms. The Credit River Watershed has traditionally had a high concentration of equestrian farms and stable operations. According to the 2006 census of agriculture, 20% of the farms in the Credit River Watershed are horse farms.

As a result of relentless urban development pressures, the Government of Ontario has instituted new policies, such as the Greenbelt Plan and Places to Grow, to curb urban sprawl and protect the rural landscape. Greenbelt Legislation now largely protects the upper and middle portions of the Credit River Watershed from urban development.[7] In addition, the Credit River Watershed contains portions of the Oak Ridges Moraine and the Niagara Escarpment, which are provincially protected. Figure 3 shows what portion of the watershed the Greenbelt, Oak Ridges Moraine and Niagara Escarpment cover.

Natural resource extraction is limited throughout the watershed with the exception of aggregate mining. A total of 1,535 ha of the watershed are currently devoted to aggregate mining. In 2006 the Town of Caledon, located within the watershed, was the fifth largest aggregate producing municipality in Ontario, extracting 5.3 million tonnes of material.[8]

While the lower portion of the watershed is an urban dominated landscape, the middle and upper portions provide a number of unique recreational opportunities for urban residents. The Bruce Trail, for example, follows the Niagara Escarpment over 800 km from Tobermory to Niagara Falls and runs through the middle portion of the watershed. In addition, the river provides high-quality fly-fishing opportunities and one of the few remaining cold water fisheries in Southern Ontario. Beyond the recreational activities, the middle and upper portions of the watershed provide the vital resources that support the Credit Valley's agricultural community. As a result of this agricultural activity, numerous small settlements are dotted throughout, historically supporting the local agricultural community, and more recently have become growing population centres as residents move to the countryside and commute to work.

---

[7] Government of Ontario, "Protecting the Greenbelt: Greenbelt Act, 2005," www.mah.gov.on.ca/Page195.aspx (accessed January 21, 2008).

[8] Ontario Aggregate Resources Corporation, *Mineral Aggregates in Ontario: Production Statistics 2006* (Burlington, ON: 2006), www.toarc.com/pdf/Stats_2006.pdf.

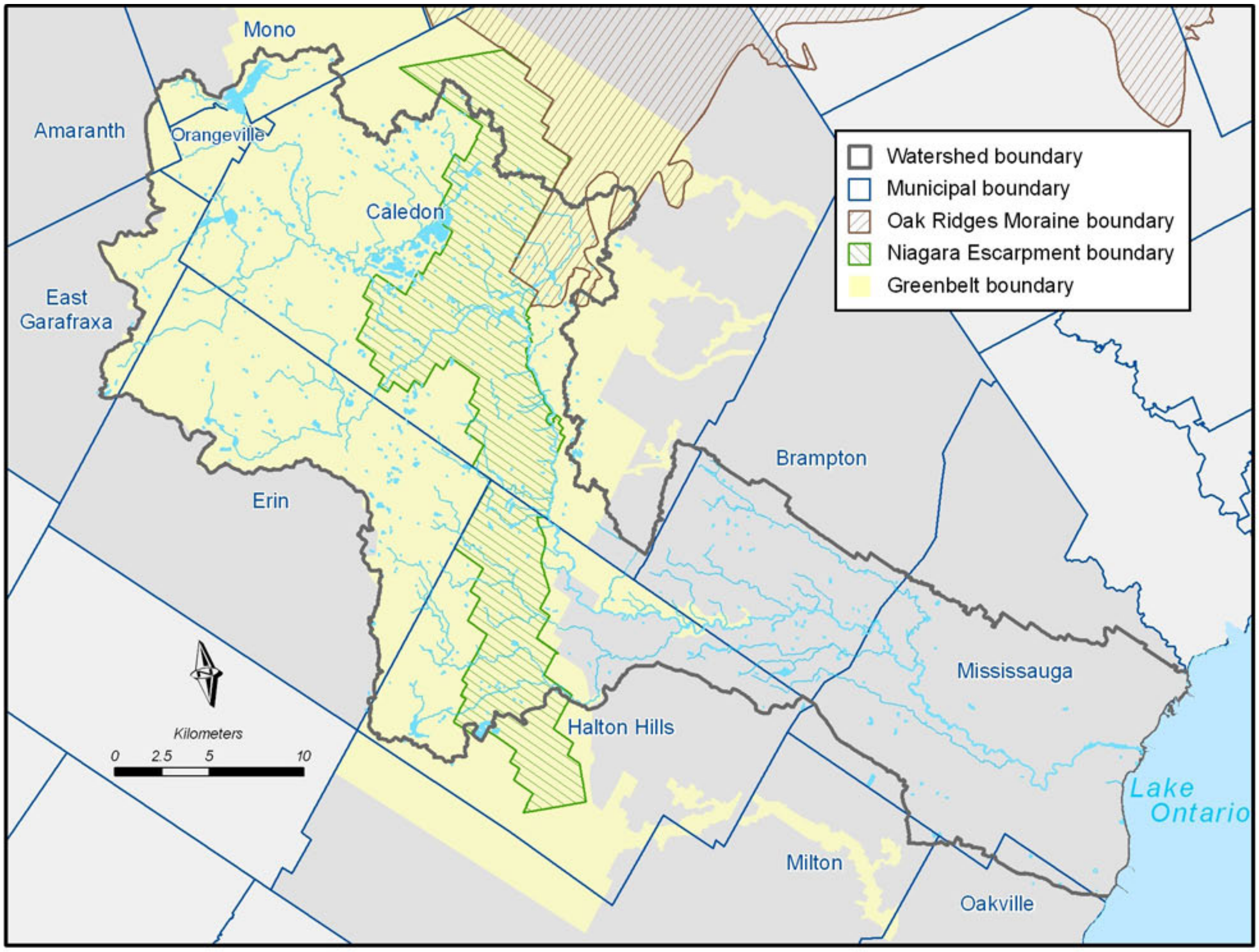


Figure 3. The Greenbelt, Oak Ridges Moraine and Niagara Escarpment all cut through the Credit River Watershed

Source: Credit Valley Conservation 2008

2.3 Ecological Land Classification and Land Cover

The first step toward accounting for natural capital is to determine what natural features and/or resources exist. CVC keeps detailed information on this through the use of the Ecological Land Classification system developed for southern Ontario.[9] Under this land classification system, natural features are divided into a number of small spatially explicit units containing specific vegetation and environmental conditions where the smallest unit is generally 0.5 ha in size. In addition to the Ecological Land Classification data, CVC has also developed a system for mapping existing land uses, such as intensive agricultural, urban development and active aggregate mining.

---

[9] Harold Lee, Wasyl Bakowsky, John Riley, Jane Bowles, Michael Puddister, Peter Uhlig and Sean McMurray, "Ecological Land Classification for Southern Ontario: First Approximation and its Application," SCSS Field Guide FG-02 (Toronto, ON: Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch, 1998).

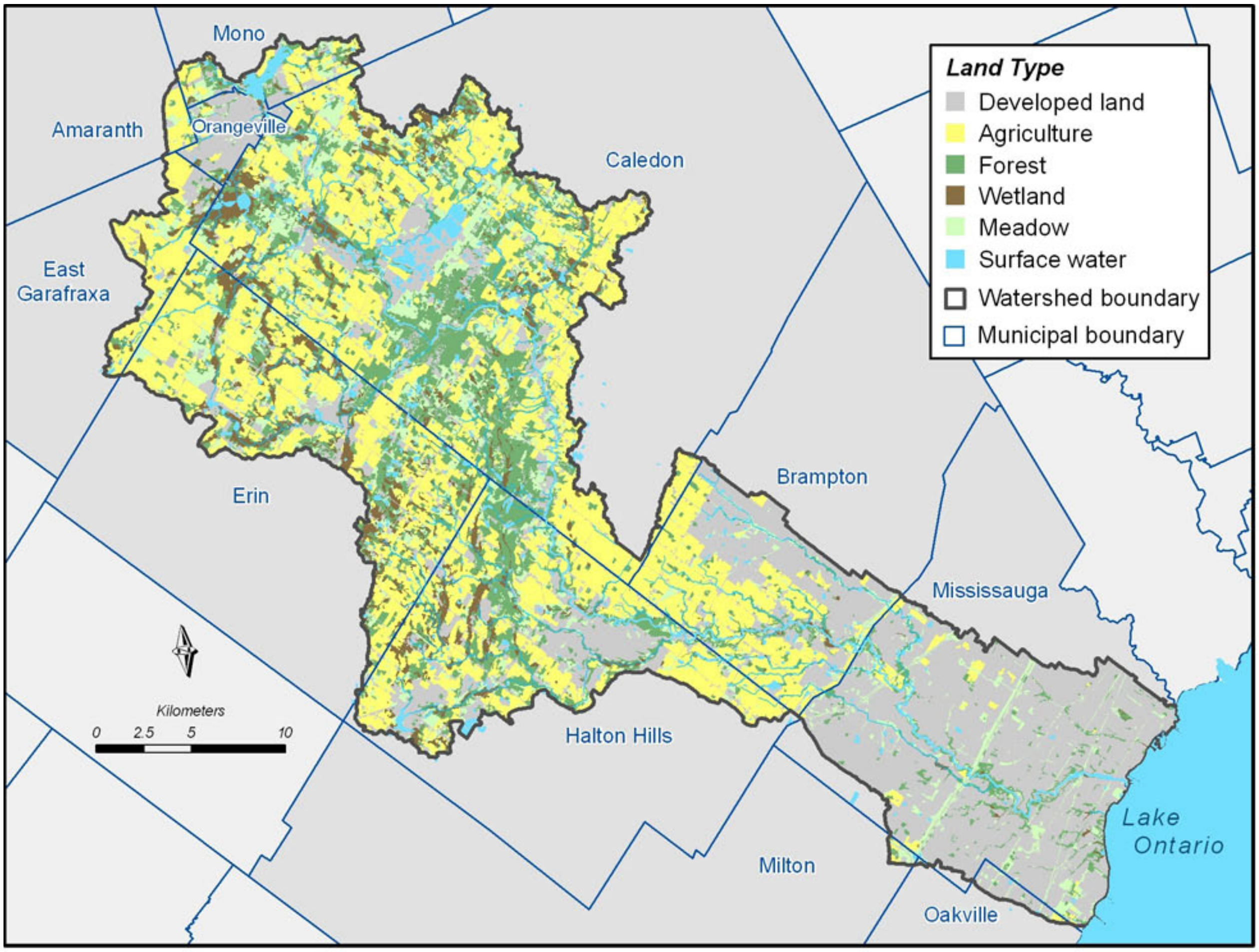


Figure 4. Land cover types in the Credit River Watershed

Source: Credit Valley Conservation 2008

The Ecological Land Classification of natural land cover and CVC's land-use mapping combine to provide complete landscape coverage for the Credit River Watershed (Figure 4).

Land use in the watershed heavily favours agriculture (31,158 ha) and urban use (31,151 ha), which together cover about 66% of the watershed. Forests (15,681 ha) and wetlands (5,896 ha) cover about 23% of the watershed, but they have been fragmented by urban and agricultural land uses. Meadows (9,917 ha) are the other major land cover, covering about 10% of the watershed. Meadows are defined as land cover that is in a state of natural regeneration after cultural or human-based disturbances, such as an abandoned farm field. (Meadows are referred to as cultural communities in the Ecological Land Classification).

2.4 Threats to Natural Capital in the Credit River Watershed

The health of the Credit River Watershed, like many other watersheds in populated areas of North America, is threatened from extensive urban and suburban sprawl, which weaken the resilience of remaining natural features and their ability to provide ecological services. Today, pressures on the watershed's ecosystem are intensifying. Understanding the scale of the threats is important — these are discussed below.

2.4.1 Land-Use Change and Urban Development

One of the most significant threats to Credit River Watershed health is land-use change, particularly the conversion of rural landscapes to urban ones. The conversion of natural capital to urban areas characterized by impermeable surfaces, such as roads and rooftops, generally implies a complete loss of ecological services that would be provided by the unconverted land, in addition to diminishing the wider ecosystem's ability to provide goods and services. Current impervious cover has been estimated at about 15% of the watershed. It is expected to increase to 25% based on approved future developments.[10]

Increased urban development has a number of impacts on the natural environment, which causes increased wastewater disposal, increased storm water run-off and peak river flows, increased sediment erosion and deposition, degradation of aquatic habitats, increased water temperatures, and reduced groundwater discharge and recharge. Recently, the *Credit River Water Management Strategy Update* examined development impact on watershed conditions. It found that continuing current development practices and infrastructure management (i.e., business as usual) would significantly impair the watershed.[11]

2.4.2 Climate Change

Global climate change threatens all ecosystems, and the Credit River Watershed is not immune to these impacts. The expected impacts of climate change relevant to the Credit River Watershed were discussed in a recent report issued by the Department of Natural Resources Canada[12] and this study predicts that expected impacts of climate change on the region include projected decreases in seasonal water supply, decreases in spring flooding, and increases in the frequency and intensity of extreme rainfall events. Within the last five years, local data indicates that on average the mean monthly precipitation levels increased 32% for May and June while simultaneously decreasing 46% during August.[13] While it is difficult to attribute such trends to human induced climate change, these numbers indicate that climate variability, whether natural or human induced, can be significant and potentially threaten ecosystems in the Credit River Watershed.

Within the floodplain of the Credit River and its tributaries, 22 flood damage centres have been identified and monetary damages have been estimated for each damage centre. Total damages for the watershed were estimated to be $7.7 million and $6.5 million for a 1-in-50 and a 1-in-25 year flood, respectively.[14] Under a changing climate it is expected that we will experience more severe weather events. Climate change could result in increased flood frequency implying that flood damage would occur more frequently. In other words, the 1-in-50 flood could become a 1-in-25 year flood, meaning the probability of experiencing more costly flooding events rises.

---

[10] CVC, *Credit Valley Conservation Strategic Plan 2006* (Mississauga, ON: Credit Valley Conservation, 2007).

[11] CVC, *Credit River Water Management Strategy Update.* (Mississauga, ON: Credit Valley Conservation, 2007).

[12] Quentin Chiotti and Beth Lavender, "Ontario" in *From Impacts to Adaptation: Canada in a Changing Climate 2007*, D. Lemmen, F. Warren, J. Lacroix and E. Bush, eds. (Ottawa, ON: Government of Canada, 2008), 227–74.

[13] CVC, *Watershed Report Card: A Detailed Summary of the Ecosystem Health of the Credit River Watershed* (Mississauga, ON: Credit Valley Conservation, 2005).

[14] C. J. Schuster, S. Murray and E. A. McBean, *Vulnerability Characterization, Mapping, and Assessment: A Study of Flooding Scenarios for the Credit River Catchment* (Guelph, ON: School of Engineering, University of Guelph).

2.4.3 Waste and Pollution

Pollution as a result of a spill or abnormal discharge of hazardous material to the natural environment has occurred regularly throughout the watershed. Such spills may include wastewater treatment plant bypass (i.e. untreated wastewater being discharged directly into the river), leaching from landfill sites, or other industrial and private residential spillage. Since 1982, municipalities within the watershed have reported more then 6,000 such spills,[15] or on average more than 240 per year. As well, the 2006 Credit Valley Conservation Strategic Plan identified widespread disposal of hazardous chemicals down local storm sewers and sediment as being a major issue.

Rural pollution originating from poor agricultural practices, landfill sites, golf courses and residential subdivisions has also been identified as a potential threat. Generally speaking, intensive agriculture is limited in the watershed and is not considered a significant source of pollution. However, in some areas of the watershed there is evidence of fertilizers contaminating groundwater aquifers. In addition, increased rural development has led to higher densities of septic systems and road salting providing potential threats to water quality throughout the watershed.

[15] CVC, *Credit Valley Conservation Strategic Plan 2006.* (Mississauga, ON: Credit Valley Conservation, 2007).

3. Study Approach

The natural capital in the Credit River Watershed was estimated through a series of benefit transfers focusing on the value of non-market ecological services provided by the watershed. Benefit transfer is now common in applied analysis of ecological services.[16] There still remain a number of methodological questions about benefit transfer approach, but in cost-benefit analysis decision-making, when resources and time are constrained, benefit transfer can be an effective means to bring the non-market value of ecological services into decision making.[17]

For the purposes of this analysis, the study area was confined to land within the watershed boundary. However, it should be recognized that ecosystem functions and associated ecological services often cross watershed boundaries and are dependant on the health of surrounding watersheds. Further, while benefits accounted for in this analysis were applied strictly to residents of the watershed, it is important to note that benefits of the Credit River Watershed's natural capital extend to those living beyond its boundaries. For this reason, among others, estimates in this report should be considered a minimum lower bound of the total value.

3.1 Natural Capital Valuation Framework

Economic value measures the degree to which the provision of a good or service satisfies an individual's preferences. Typically, our preferences are revealed through a decision to buy or not to buy goods and services. If an individual decides to purchase good A, he or she is willing to pay at least as much as the price of good A. In this way we can use the willingness of an individual to pay as a measure of their level of satisfaction derived from the good or services (i.e., economic value).

From an economic perspective, natural capital (the stock of natural assets in the watershed), derives value from the flow of goods and services it produces over time, because these ecological services provide satisfaction to humans (i.e., improve human well-being). Therefore, an individual's willingness to pay for an ecological service is how a value is attributed to natural capital.

The concept of total economic value (TEV), typically employed in environmental valuation, suggests that economic value is the sum of use values and non-use values, which are further subdivided, as outlined in the Figure 5. Ecosystem valuation seeks to capture use and non-use values associated with non-market aspects of ecological services. This framework has been

---

[16] Stale Navrud and Richard Ready, eds., *Environmental Value Transfer: Issues and Methods* (Dordrecht, Netherlands: Springer, 2008), 1.

[17] W. H. Desvouges, F. R. Johnson and H. S. Banzhaf, *Environmental Policy Analysis with Limited Information: Principles and Applications of the Transfer Method* (Northampton, MA: Edward Elgar, 1998).

discussed in the literature in extensive detail.[18] While the TEV framework is accepted in the literature, generating estimates of benefits for each of the categories listed is not always possible. What is important to note is that this framework reflects the types of values that society generally places on the environment.

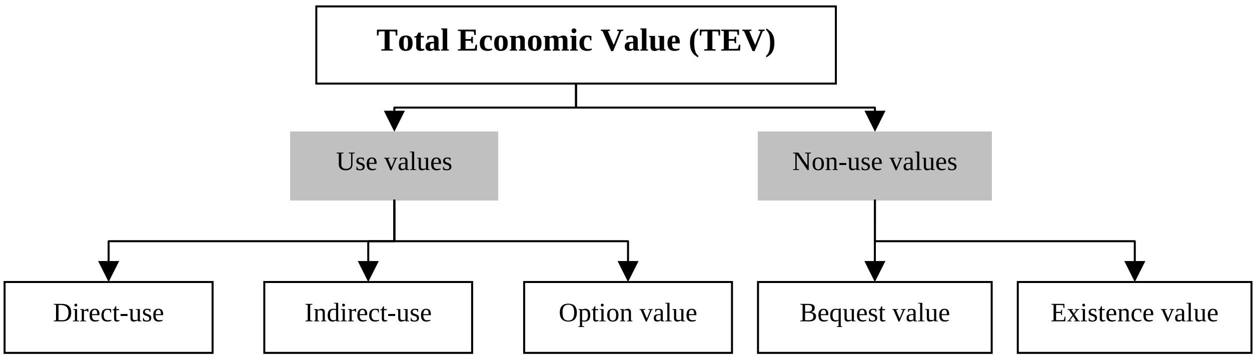


Figure 5. Total economic value framework for environmental valuation
Source: National Research Council of the National Academies, 2003

As Figure 5 depicts, services afforded to society by ecosystems can be categorized into two main values: use and non-use. Use values reflect the value derived by humans from consumption (directly or indirectly) of services, or from having the option of consuming them at some point in the future. Use values are of three types:

- **Direct-use value:** derived from direct use of the ecosystem or resource, such as the value of water for drinking.
- **Indirect-use value:** derived from indirect use of the ecosystem or resource, such as the value of a wetland for flood control.
- **Option value:** derived from preserving a use value of water today for the option of using it in the future, or preserving forest biodiversity today so that it may be available in the future.

Non-use values, in contrast, are derived without consumption taking place. Non-use values (also referred to as the inherent values) are of two types:[19]

- **Bequest value:** satisfaction that individuals derive from the knowledge that flood control exists for future generations.
- **Existence value:** satisfaction of knowing that nutrient cycling exists.

While many ecological economists recognize that, in theory, values held for the environment cover a broad spectrum, from direct use to non-use (Figure 5), it is often complicated and onerous to capture all components of TEV and attempting to measure TEV can lead to double counting of benefits. The description above is a good way to highlight the breadth of value held for natural capital. Actual measurements tend to be more simplistic.

---

[18] Eric Plottu and Beatrice Plottu, "The concept of Total Economic Value of environment: A reconsideration within a hierarchical rationality," *Ecological Economics* 61 (2007): 52–61.

[19] The TEV framework recognized by Australia's National Oceans Office includes two additional non-use values: quasi-option values and vicarious-use values.

3.2 Land Cover Classes and Use in This Analysis

As mentioned above, the first step toward accounting for natural capital is to determine the stock of natural resources. The ecological land classification data described in chapter 2 is quite detailed. Given the lack of valuation data related to such specific land cover categories, the detailed categories were aggregated into a useable characterization for natural capital assessment. For example, marshes swamps and bogs were combined into a general wetlands category. Forest cover was a special case where deciduous and coniferous natural forests and plantations were grouped into a general forest category and then divided into upland, riparian and urban forest, as defined below. The total area of each aggregated land cover type is presented in Table 1.

Table 1. Area of Credit River Watershed by land cover type.

Land Cover Type	Area (Hectares)	Percent Cover of Credit River Watershed
Upland Forest	11,046	12%
Riparian Forest	2,709	3%
Urban Forest	1,925	2%
Wetland	5,896	6%
Agriculture	31,158	33%
Water	1,082	1%
Meadows	9,917	10%
Developed	31,151	33%
Total	**94,885**	**100%**

Each land cover type is described below.

Upland Forest

Forests in the watershed are composed of a number of different forest types encompassing a wide variety of species. Upland forest was defined as all general forest not considered included in riparian or urban forest.

Riparian Forest

Riparian forests are those that stretch for 15 m on either side of a water body. The separation of riparian forest from general forest was done due to the unique importance, and thus higher value, for water quality, aquatic habitat and recreation provided by forest in riparian areas.

Urban Forest

Urban forest represents all forested areas in the watershed that are within the limits of major urban centres (Mississauga, Brampton, Orangeville and Georgetown), excluding any riparian forest that occurred within urban centres.

Wetlands

Wetlands represented areas that were classified under the Ontario Ecological Land Classification as swamps, bogs or marshes.

Agriculture

Agriculture encompasses those land covers in the watershed that host intensive, non-intensive agriculture activity.

Water

Water land cover represents all measured water bodies (streams, rivers and lakes) within the watershed boundaries.

Meadows

This land cover represents land that has been disturbed by humans. The previous land use was typically agriculture and is now moving through various early stages of succession.

Value of Natural Capital in the Credit River Watershed

LAND COVER	UPLAND FOREST	RIPARIAN FOREST	WETLAND	WATER	URBAN FOREST	MEADOWS	AGRICULTURE
Ecological Services	Atmospheric Regulation Climate Regulation Disturbance Avoidance Water Regulation Water Supply Pollination Habitat Recreation	Atmospheric Regulation Climate Regulation Water Supply Waste Treatment Pollination Biological Control Habitat Biodiversity Recreation Culture	Climate Regulation Water Regulation Water Supply Soil Formation Nutrient Cycling Waste Treatment	Water Regulation Water Supply Soil Formation Waste Treatment Habitat Biodiversity Recreation	Atmospheric Regulation Climate Regulation Water Regulation Water Supply Recreation Culture	Climate Regulation Pollination Habitat Recreation	Climate Regulation Pollination Habitat

Figure 6. Land cover classifications and accompanying ecological services characterization used in this study.

Illustration: Rob Weidemann, Über Communications

3.3 Benefit Transfer Procedure

Data requirements to assess all ecological services provided by natural capital are fairly intensive. For many services, primary studies simply have not been conducted, thereby limiting the data available to be transferred. Given limited data availability, the following decision rule was used for deciding which transfer method to use:

- Where a reasonably similar benefit estimate existed, unit values were used and adjusted based on expert judgement.
- Where no reasonably similar benefit estimate existed, no value was transferred.

3.3.1 Literature Review and Collection

Literature review and collection of studies focused on gathering as many primary natural capital valuation studies as possible that were particularly relevant to the Credit River Watershed. The studies sought were those that quantified the value of land cover types or ecological services that matched the classification used in this study.

3.3.2 Natural Capital Database Development

Following study collection, value estimates from primary valuation studies were entered in a database where they were stored along with a number of other attributes essential for assessing transfer effectiveness. Once the database was populated, the most appropriate values for the Credit River Watershed were selected, adjusted and applied to the watershed (Figure 7).

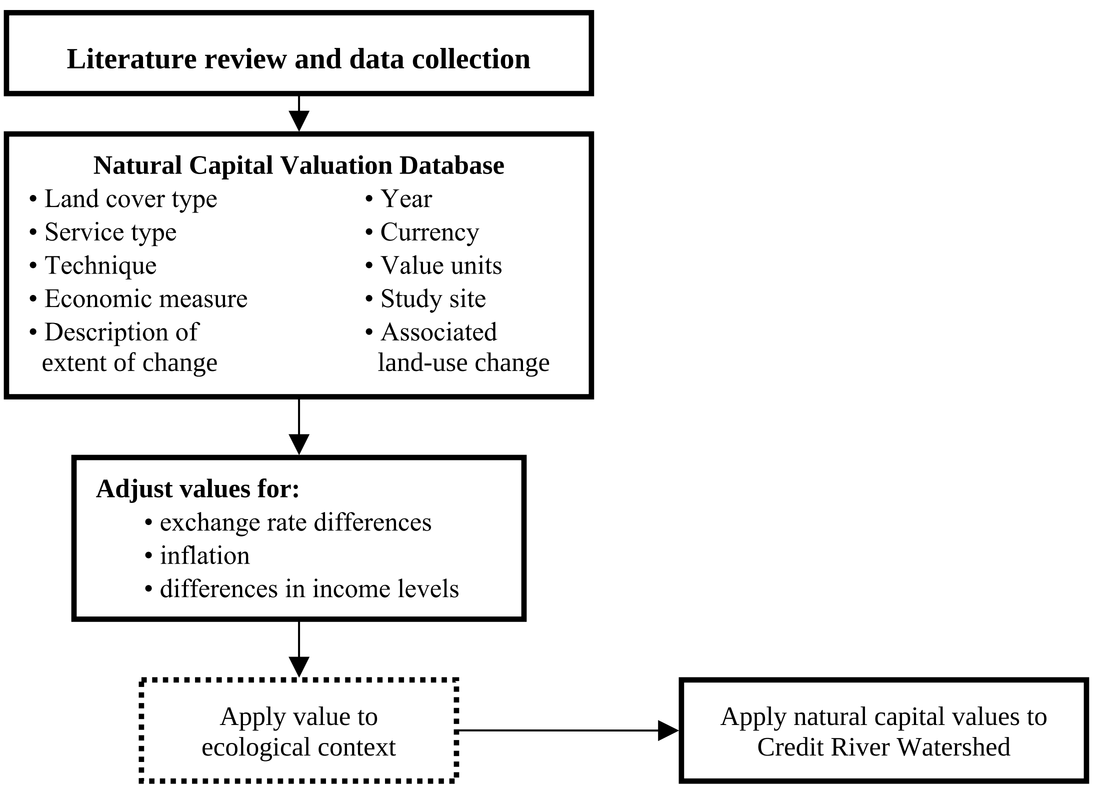


Figure 7. Framework used in this study to conduct benefit transfer

This database serves as the databank for studies used in this analysis. Further, as more research is conducted in this area, additional studies will be added and the natural capital assessment updated to reflect best available valuation information. For simplicity of data management, the database structure is meant to reflect a simplified version of what is included in the Environmental Valuation Reference Inventory[20] maintained by Environment Canada and is populated by studies relevant to the Credit River Watershed.

3.3.3 Transfer Decision Rules

To adequately transfer values from primary studies to the Credit River Watershed context, a number of rules were devised that enable a consistent and rigorous benefit transfer approach. The following protocols were used to transfer values from the original study site:

- Maintain the original unit-value estimate. Many estimates were made in various units of measure (per person per year, per household per year, per hectare, per kilometre of shoreline, etc.). Every effort was made to maintain the original units of value estimates.
- Maintain the original context of the value estimate. Value estimates are generally computed in a particular ecological context, especially in the case of contingent valuation. In this regard, estimates may concern a wetland, a lake, a stream or a forest. When these estimates are used in the analysis, they were applied in the same manner as they were derived.
- Adjust values for currency differences. Primary studies were used from regions in Europe and the U.S., so currency estimates were transferred to Canadian dollars based on the estimate year's exchange rate.
- Adjust values to the base year of 2007. The primary studies collected have a number of different years in which estimates were made.

3.3.4 Applying Values to the Credit River Watershed

Once the database of values was developed and adjustments were made, the natural capital values were applied to the Credit River Watershed. The most effective means to apply values to the watershed was through CVC's geographical information system (Figure 8).

Depending on how the initial value was estimated, some values are not reported as annual values. For example, some studies estimate people's willingness to pay a one-time fee to protect a given ecological service. In such cases it is necessary to convert these one-time willingness to pay values to annual values in order to state all services in common terms. To make such a conversion, the standard financial relationship between present value, future value and annual annuity payments was used. All ecological service values were converted to 10-year annuity payments, based on a discount rate of 2%.

Applying Natural Capital Flow Values

The flow of ecological services will continue to provide value indefinitely into the future, provided we invest in our natural capital. Consequently, one might think that values should be assumed to exist in perpetuity. However, many of the values transferred for this study are based

[20] For more information on the Environmental Valuation Reference Inventory, see www.evri.ca.

on stated preferences of today's citizens. Tomorrow's citizens are quite likely to hold different values than today's. In addition, the current state of natural capital is under threat, as discussed in the previous chapter. As remaining natural capital becomes increasingly scarce, *its value rises exponentially*. Therefore, we assume that the value of ecological service flows in the Credit River Watershed are valid for only the next 10 years, highlighting the need to continually monitor people's preferences and values within the context of existing environmental conditions.

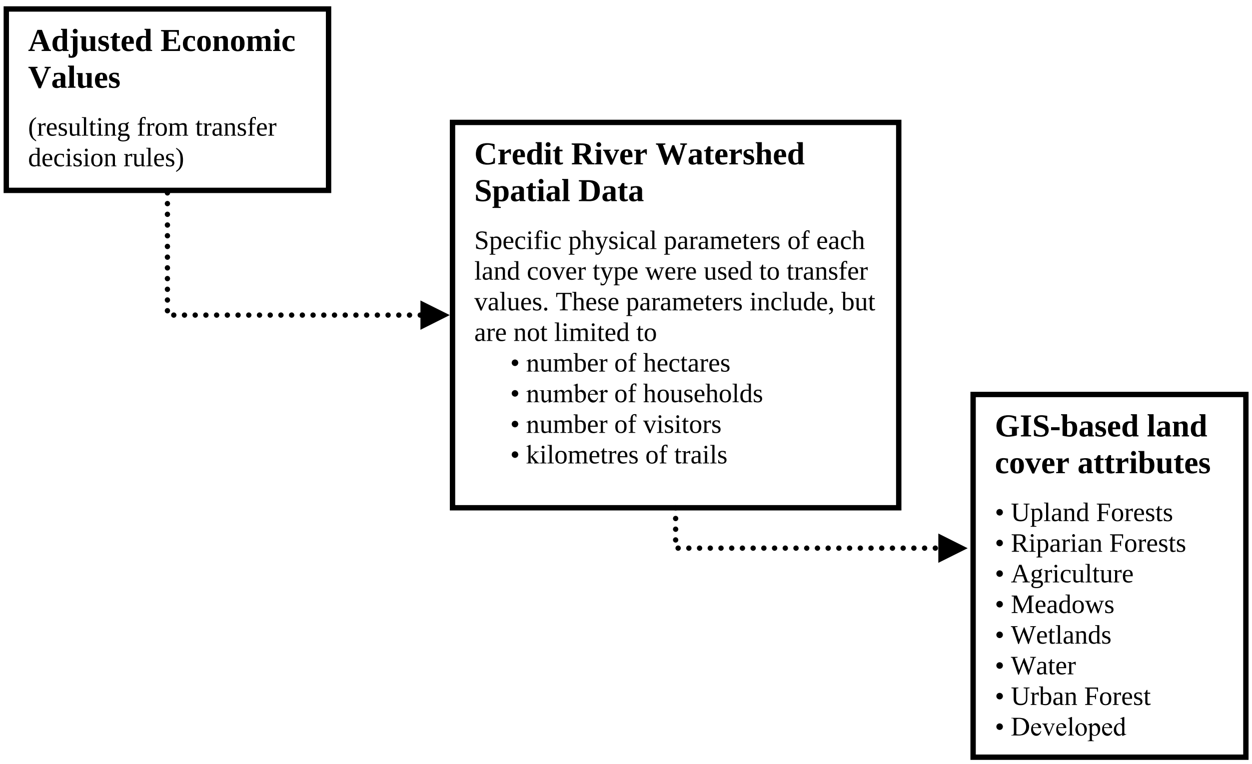


Figure 8. The process followed to assign adjusted economic values to the unique ecological attributes of the Credit River Watershed

Applying Natural Capital Stock Values

As mentioned in section 3.1, the flow of benefits from ecological services over time is why natural capital is valuable. As a result, the stock value of natural assets in the land base (forests, wetlands, meadows and agriculture land) can be estimated as the present value of the flow of benefits over time. This capital value, termed capital stock value, provides an estimate of the expected value of the flow of ecological service benefits provided by natural assets in the same way the value of a financial instrument can be measured by expected future payment flows.

It should be noted that within the context of converting future benefit flows to a present stock value of natural capital, a social discount rate is used, as opposed to an interest rate typically used in financial applications. This is because future flows are discounted under the assumption that benefits today are preferred to benefits tomorrow. In other words, the social discount rate is the rate at which society is willing to trade off use of services today for use in the future. However, the application of discount rates is not without criticism. Large discount rates give less weight to future benefits, which leads to greater resource use today at the expense of future generations. If the discount rate is assumed to be zero, then the natural capital value is infinite.

Uncertainty, risk, intergenerational equity and potential irreversibility of policy decisions imply that the social discount rate should be lower than interest rates set by traditional capital markets.

3.4 An Example of the Method Used in This Report

One of the most valuable services a healthy watershed provides its residents is a supply of clean drinking water. There are two main sources of drinking water for the residents of the Credit River Watershed: Lake Ontario for people who live in Mississauga and Brampton, and groundwater for the remaining communities. While the health of the watershed affects the quality of water being taken from Lake Ontario, data limitations made it impossible to quantify this relationship.

In the middle and upper watersheds, residents depend on local groundwater as a water source. As a result, they depend on the health of forests and wetlands that continue to filter (i.e., purify) and replenish groundwater supplies. If these services were no longer available, the next most likely supply of water would be Lake Ontario.

In the mid-1990s, Environment Canada undertook a study that assessed groundwater value in the Town of Caledon, a portion of which is located in the Credit River Watershed.[21] The study found that the existence of groundwater avoided the cost of pumping water from Lake Ontario, which was estimated to be $6.84 (2007 CAD) per cubic metre of water. Recent estimates by CVC show that annual groundwater consumption is more then 14.7 million m^3. Therefore, the supply of water that forests, wetlands, meadows and agricultural land covers provide for free would cost approximate $100.5 million (2007 CAD) per year to replace.[22]

This valuation represents an example of an ecological service valuated in this report. Chapter 4 provides more detailed information on all ecological services valuated in this analysis. It is noteworthy that the economic value of the ecological service is transferred based on flow of the service in the Credit River Watershed, as opposed to transferring an average per-hectare value.[23]

3.5 Study Limitations

As mentioned throughout the report, this study provides a partial estimate of the baseline value of ecological services in the Credit River Watershed. With the exception of one study conducted by CVC on the value of recreational fishing, no primary research on ecological service valuation has been done in the Credit River Watershed. Therefore, many of the values were transferred from studies outside of the region. Due to this fact, it was not possible to derive estimates for all ecological services.

---

[21] Marg Troyak, *An Assessment of the Ecological and Economic Value of Groundwater: Town of Caledon Case Study* (Environment Canada, Ontario Region, 1996).

[22] It should be noted that water supply was measured solely based on the avoided costs of lost groundwater. In order to apply this value to land covers we assumed that all land covers excluding development maintained this service. Unfortunately, we were unable to connect the water supply value to land cover in a more rigorous manner.

[23] However, in some cases (as outlined in the next section), data limitations forced the use of average per hectare when transferring values.

Indeed, further information about the link between natural capital stocks and their flow of ecological services is needed to adequately assess functioning ecosystems and then apply value to these functions. Lack of data is a huge limitation for the work of valuing ecological services. As such, more investment of time and resources should be put to this aim by all governments.

Further, it is has been recognized that a threshold of critical natural capital is needed in order for humans to survive on earth. Theoretically, as our stock of natural capital approaches this critical threshold, its value approaches infinity because without it we would cease to exist. This study attempts to capture the notion that the environment provides significant values that need to be more carefully considered in the decision-making process.

In all instances the numbers presented in this study should be considered a minimum lower bound of the total value of ecological services in the Credit River Watershed. The three main reasons why the total values reported in chapter 4 should be considered a minimum lower bound are as follows:

1. Due to the complexity of trying to estimate the values held by non-residents, we restricted our estimate to only measure the benefits to those households that live within the watershed.
2. Due to data limitations, only a small selection of the ecological services were estimated for the watershed. Therefore, the natural capital value can only be interpreted as a partial estimate.
3. In cases where data limitations forced us to make assumptions, the most reasonable conservative assumption was applied.

It is also important to note that if values developed in this analysis were used for decision-making rather than educational purposes (which is the primary purpose of this assessment), then cost and benefit curves for each ecological service would need to be developed to properly assess the marginal benefit and marginal cost to adequately conduct a trade-off analysis between conserving ecological services and any development proposal.

4. Value of Natural Capital in the Credit River Watershed

This section provides results of the analysis performed for this study. First, we highlight the value of natural capital in the Credit River Watershed followed by estimates for each land cover type.

4.1 Value of Natural Capital Flows by Ecological Service

Table 2 presents estimated value per capita and total annual value provided to residents of the Credit River Watershed by its natural capital. At a minimum, the total value of the watershed was estimated at $371 million per year. As shown in Table 2, waste treatment was found to be the most valuable ecological service provided in the Credit River Watershed, providing an annual service value of $137 million per year.

Table 2. Value of natural capital by ecological service in the Credit River Watershed (2007 $CAD)

Ecological service	Average value per capita per year ($)	Total annual value ($ millions)*
Climate regulation	54	41.0
Gas regulation	8	5.9
Disturbance avoidance	21	16.1
Water Supply	133	100.5
Waste treatment	181	137.1
Pollination	5	4.0
Habitat	11	8.6
Recreation	18	13.6
Amenity & Cultural	12	9.3
Bundled Riparian Services	46	35.0
Watershed Total	490	371.1

* These values should be considered a minimum lower bound of the natural capital value for the reasons outlined in section 3.5.

To better understand the estimates provided in Table 2, the descriptions below describe how the benefit transfer was conducted. All estimates presented in Table 2 are in 2007 Canadian dollars. *It should be noted that it was not possible to estimate all ecological services. Therefore these* *estimates should be considered a minimum lower bound of the true value of ecological services provided by the watershed.*

4.1.1 Climate Regulation

Climate regulation is one of the most important services provided by forests and other related vegetation to help society mitigate and adapt to climate change. Climate regulation is measured in this analysis through two processes that function on land with tree or plant cover: carbon sequestration (uptake of carbon) and carbon storage (banking of carbon).

To measure the climate regulation contribution from land cover types assessed in this report, we adapted the method established by Sara Wilson and published in the Greenbelt Study.[24] This study was particularly relevant to the Credit River Watershed because more than 65% of the watershed is covered by the Greenbelt area (see Figure 3). In this regard, we referenced the average annual value of carbon stored by forests in the Credit River Watershed to be 220 tonnes per hectare of forested land. The price of carbon used in this analysis was $55 per tonne of carbon.[25] This number coincides with the price used in the Greenbelt study and a number of studies that have estimated the social cost of carbon.[26] In fact, the literature suggests that $55 per tonne of carbon is a conservative estimate.[27]

To estimate the carbon storage service provided by each land cover type we, again, followed the same method used by the Greenbelt study. The annual removal of carbon dioxide was estimated to be, on average 0.75 tonnes of carbon per hectare for the forest[28] and 0.375 tonnes of carbon per hectare for meadows.[29] An estimate of carbon sequestration by agricultural land cover was not performed because a reasonable estimate of carbon sequestration by agricultural crops was not available.

The total value of climate regulation was estimated to be $104.5 million. Because this amount is the total value of carbon for the forests, however, it was then transferred into a 10-year annuity, which resulted in an annual value for climate regulation of $11.4 million for forests. The same process was followed for climate regulation provided by riparian forests,[30] urban forests, meadows[31] and agricultural[32] land cover to provide an aggregate value for climate regulation of $41 million per year.

---

[24] Sara Wilson, *Ontario's Wealth Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services*, prepared for the David Suzuki Foundation, 2008.

[25] This price represents the social costs of carbon as estimated in the U.K. However, current market prices for carbon are only $15 per tonne. We chose to use the social costs because the focus of this report is on identifying and valuing external social costs.

[26] Richard Clarkson and Kathryn Deyes, *Estimating the Social Cost of Carbon Emissions* (HM Treasury and U.K. Department of Environment Food and Rural Affairs, Government of U.K., 2004).

[27] Ibid.

[28] Includes the upland forest, urban forest and riparian forest land cover types.

[29] Meadows are assumed to have a tree cover percentage that is half of that of the forested land covers.

[30] The value of carbon stored in riparian forests and urban forests was assumed to be the same as that of the upland forests.

[31] The value of carbon stored in cultural land covers was assumed to be half of that stored by upland forests.

It is important to note that this estimate represents a fixed estimate and does not capture the flux that generally occurs in forest carbon sequestration. Further analysis can be done using the Canadian Forest Service's Carbon Budget Model for forested lands to refine per-hectare estimates of forest carbon. For agriculture lands, the Canadian Soil Organic Database can provide more detailed estimates of carbon stored in agricultural land covers.

4.1.2 Gas Regulation

Forests also play an important role in removing pollutants from the air, such as carbon monoxide, ozone, nitrogen dioxide, particulate matter and sulphur dioxide, while producing life-supporting oxygen. To estimate the benefit that residents of the Credit River Watershed gain from air purifying services, we relied on the detailed work done for the Greenbelt.[33] Using information outlined in Table 3, and applying it to upland, riparian and urban forest cover in the Credit River Watershed, air purification services were estimated to be $5.9 million per year.

Table 3. Value of air pollution removed by forest cover in the Credit River Watershed

	Kilograms of pollutant removed per hectare	Value per kilogram of pollutant removed ($)	Value per hectare of pollutant removed ($)
Carbon Monoxide	1.2	1.04	1.25
Ozone	30.3	7.51	227.59
Nitrogen Dioxide	7.5	7.51	56.34
Particulate Matter	16.8	5.01	84.25
Sulphur Dioxide	4.2	6.29	7.71
Totals	**60.0**	**6.29**	**377.14**

Source: Sara Wilson, *Ontario's Wealth Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services*, prepared for the David Suzuki Foundation.

4.1.3 Disturbance Avoidance

The ability of natural environments to shield us and our infrastructure from the effects of wind, waves and flood waters resulting from extreme weather is a valuable contribution of natural capital. Most relevant to the Credit River Watershed is its ability to regulate peak river flows and mitigate flood damages. Forests and wetlands play key roles in providing this service. Wetlands act like a sponge during peak flows and soak up high volumes of water, slowly releasing water to the river channel over time, dampening peak flows. During heavy rainfalls forest and other natural features such as those we have defined as meadows reduce the speed and quantity of runoff reaching the river channel reducing peak river flow and soil erosion.

---

[32] The value of carbon stored by agriculture land covers was estimated to be 80 tonnes per hectare. This estimate was based on the average soil carbon content reported by Sara Wilson in *Ontario's Wealth Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services*.

[33] Sara Wilson, *Ontario's Wealth Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services,* prepared for the David Suzuki Foundation, 2008.

A study conducted by the National Round Table on the Economy and Environment examined the benefits of converting agricultural land to natural cover in the Grand River Watershed,[34] a watershed that borders the western portions of the Credit. This study showed that increased natural cover reduced the costs of flooding in terms of reduced sedimentation damage by an average of $5.47 per hectare per year.[35] Because there are 11,046 ha of upland forest cover in the Credit, the benefit of forest cover in reducing sediment damage from flooding events could be worth $60,430 per year. We used the same method to assess the benefit of meadows. However, because meadows are dominated by field cover rather than dense tree cover, its service has a lower level of effectiveness. Consequently, the lower value reported in the study ($2.39 per hectare per year) was used, resulting in a value of $23,737 per year. It should be noted that these benefit values are conservative because data limitations did not allow them to account for the avoided cost of property damage.

Flood control services provided by wetlands have been studied much more extensively. However, only one study we found was similar enough in the scale of analysis and in environmental and demographic conditions to that of the Credit to warrant being transferred. This study estimated the avoided damage costs from water storage of wetlands in the Charles River Watershed in Massachusetts to be $2,711 per hectare per year,[36] implying that wetlands in the Credit River Watershed reduce the damage costs by $16 million per year.

4.1.4 Water Supply

Water supply services provided by the watershed where estimated to be $100.5 million per year. Details of this calculation were highlighted in section 3.4 as an example of the benefits transfer method.

4.1.5 Waste Treatment

The natural environment is very good at cleaning up human waste. Waste treatment is one of the most valuable services wetlands and water provide. Specifically, wetlands naturally remove excess nitrogen and breakdown many contaminants from human waste. The Charles River Watershed study mentioned above found that the complete loss of wetlands would cost $22,898 per hectare per year.[37] Transferred to the Credit River Watershed (which is similar in size and in economic and environmental attributes), wetlands provide $135.5 million per year in waste treatment services. In addition, a study done in Ohio found that each resident was willing to pay

---

[34] Ken Belcher, Cythia Edwards and Brian Gray, *Ecological Fiscal Reform and Agricultural Landscapes, Analysis of Economic Instruments: Conservation Cover Program* (Ecological Fiscal Reform, National Round Table on the Economy and Environment, 2001).

[35] In the Greenbelt study, storm water runoff savings where calculated using a GIS-based software and an assumed avoided construction cost of $57 per cubic metre of reduced storm water generating an average value of $1,523 per hectare of forest. Since we were unable to effectively assess the reduction in water volume that the Credit's forest provide, we were unable to maintain the original unit-value estimate, one of our decision criteria and chose to use $5.47 per hectare per year, recognizing that this is a significant under estimate.

[36] Francis Thibodeau and Bart Ostro, "An Economic Analysis of Wetland Protection," *Journal of Environmental Management* 12 (1981): 19–30.

[37] Francis Thibodeau and Bart Ostro, "An Economic Analysis of Wetland Protection," *Journal of Environmental Management* 12 (1981): 19–30.

a one time fee of $32.74 in order to protect the assimilative capacity of surface water.[38] Based on the watershed population, this works out to be $14.5 million, or $1.6 million per year when converted to an annuity, for the Credit River.

4.1.6 Pollination

Pollination is defined as the transfer of pollen from the male part of a plant to the female part of a plant. Many plants, including those we cultivate, require insects to perform this transfer of pollen. In fact, many field crops depend on pollination services, without which crops could not be grown. According to the 2006 census of agriculture, no farms in the Credit River Watershed reported use of domesticated pollinating bees for purposes of crop pollination. However, in the same survey, 170 honey bee colonies where reported in the watershed, which would provide some of the pollination services.

The value of agriculture occurring in the Credit River Watershed, which would not exist without the pollination services of insects, was calculated using estimates of the reliance on various crops on insects[39,40] and the value generated by those crops within the watershed (as per the 2006 agricultural census). As a result, pollination services were estimated to be almost $4 million per year. Table 4 details the calculation. Because many land cover types provide the habitat necessary to support insect population, this annual value was assumed to be contributed by agriculture, forest and meadows.

4.1.7 Habitat

Healthy natural and semi-natural landscapes provide essential habitat for flora and fauna, which many people value simply for their existence (a non-use value). The existence value of habitat services has been estimated for Grand River Watershed,[41] a watershed adjacent to the Credit River Watershed. Given the immediate proximity and similarity in ecological and socio-economic characteristics of the two watersheds, the value of conserving natural areas for the sole purpose of protecting habitat was estimated at $35.42 per household per year, for a total habitat existence value of $8.6 million per year in the Credit River Watershed. This value was considered to be supplied by upland forest, wetlands, meadows and agricultural land cover.[42]

---

[38] Stephen Irvin, Tim Haab and Fred Hitzhusen, ***Estimating Willingness to Pay for Additional Protection of Ohio Surface Waters: Contingent Valuation of Water Quality, in Economic Valuation of River Systems*** (Northampton, MA: Edward Elgar, 2007), 35–51.

[39] Edward Southwick and Lawrence Southwick, “Estimating the Economic Value of Honey Bees (Hymenoptera: Apidae) as Agricultural Pollinators in the United States,” *Journal of Economic Entomology* 85, no. 3 (1992): 621–33.

[40] John Losey and Mace Vaughan, “The Economic Value of Ecological Services Provided by Insects,” *BioScience* 56, no. 4 (2006): 311–23.

[41] James Brox, Ramesh Kumar, and Kenneth Stollery, “Willingness to Pay for Water Quality and Supply Enhancements in the Grand River Watershed,” *Canadian Water Resources Journal* 21, no. 3 (1996): 275–88.

[42] Riparian Forest habitat values were accounted for in the bundled riparian services (section 4.1.10).

Table 4. Crop values and dependence on insect pollination in the Credit River Watershed

Crop	Annual Crop Value ($)	Dependence on Insect Pollination	Annual Value Attributable to Insects ($)
Apple	1,023,946	0.9	921,552
Blueberry	30,401	0.7	21,281
Cherry	4,127	0.9	3,714
Grape	77,272	0.2	11,591
Peach	223,931	0.6	134,359
Pear	37,873	0.7	26,511
Plum/prune	13,444	0.7	9,411
Raspberry	68,015	0.8	54,412
Strawberry	558,521	0.3	167,556
Asparagus	49,960	0.9	44,964
Bean	33,029	0.1	3,303
Beat	8,797	0.1	880
Broccoli	11,894	0.9	10,705
Cabbage	96,717	0.9	87,045
Carrot	2,927	0.6	1,756
Celery	3,368	1.0	3,368
Cucumber	33,219	0.6	19,931
Lettuce	8,116	0.0	243
Onion	23,268	0.3	6,980
Pumpkin	74,234	0.9	66,810
Squash	71,453	0.9	64,308
Alfalfa	2,671,437	0.7	1,870,006
Canola (Rapeseed)	101,431	1.0	101,431
Soybean	3,145,316	0.1	314,532
Sunflower	12,079	0.8	9,663
Total	**8,384,775**		**3,956,313**

4.1.8 Recreation

Given that recreation services provided by the natural environment are probably the most obvious of ecological services, there has been considerable research effort in this area. As a result, a number of different types of studies were used in transferring values to the Credit River Watershed and extra care was taken to avoid double counting.[43]

CVC recently completed an assessment of recreational value provided by the Credit River fishery. Using the travel cost method, the study indicated the Credit River provides recreational benefits of $1.2 million dollars per year to anglers who fish the Credit.[44]

The benefit of general river recreation in an urbanized area was examined in Saskatchewan.[45] It was estimated that households were willing to pay $77.44 per year for river-based recreation. To transfer this value to the Credit River Watershed, the number of households engaging in river-based recreation was estimated by applying the willingness to pay to the number of households in the watershed that engage in outdoor activities.[46,47] This resulted in a value of $8.1 million per year. The value of fishing was subtracted to avoid double counting, which left $6.9 million per year as the benefit of non-angling river-based recreation for the Credit River Watershed.

Within the Credit River Watershed the Bruce Trail and a number of kilometres of trails converted from old railway lines provide excellent hiking opportunities to watershed residents. In Great Britain, a similar rail trail network that runs through woods and meadows provided recreational opportunities valued at $2.69 per trip based on users willingness to pay an access fee.[48] With

---

[43] We had two avenues to measure the recreational value of the Credit River Watershed: (1) to use the average economic value (the willingness to pay above and beyond actual recreational expenses) reported for all outdoor activities in Ontario from the Importance of Nature to Canadians survey; and (2) to select a number of valuation studies from the literature relevant to the Credit River Watershed that measure the economic value of specific recreational activities. On the surface, our choice of the latter method might seem strange given we have transferred values from Saskatchewan and Europe. However, it allowed us to more carefully account for the context of environmental valuation, which is extremely important when transferring values from one site to another. Transferring the average value based on all outdoor activities in Ontario would assume that recreational opportunities in the Credit River Watershed are similar to those of Ontario as a whole. However, outdoor recreation in northern Ontario is vastly different from southern Ontario. Instead, we carefully selected studies that more closely reflected the types of outdoor activities that occur in the Credit River Watershed, as well as studies that reflected the proximity to urban centres. This turned out to be the more conservative approach. The Importance of Nature to Canadians reports that people in Ontario were willing to pay on average $9.7 per person per trip for outdoor activities in natural areas. Applying this to the population of the Credit River Watershed who engage in outdoor recreation would result in a total economic value of $19.5 million per year (1996 CAD). Our approach measures recreational value of the watershed to be $13.6 million per year (2007 CAD).

[44] DSS Management Consultants, *The Credit River Watershed Valuation of Angling* (Mississauga, ON: Credit Valley Conservation, 2008).

[45] S. N. Kulshreshtha and J. A. Gillies, "The Economic Value of the South Saskatchewan River to the City of Saskatoon: (II) Estimation of the Recreational Use Value," *Canadian Water Resources Journal* 18, no. 4 (1993): 369–83.

[46] To estimate the number of households in the watershed that engage in outdoor activities, we took the number of watershed households 242,695 (from the 2006 census of population) and applied the proportion of Ontarians who engage in outdoor activities, 43% (as reported by Elain DuWors, Michel Villeneuve and Fern Filion in *The Importance of Nature to Canadians: Survey Highlights* [Ottawa, ON: Environmental Economics Branch, Environment Canada, 1999]).

[47] Due to the complexity of trying to estimate non-resident recreation, we restricted our estimate to only measure the benefits of recreation to those households that live within the watershed.

[48] K. Bishop, "Assessing the benefits of community forests: An evaluation of the recreational use benefits of two urban fringe woodlands," *Journal of Environmental Planning and Management* 35, no. 1 (1992): 63–75.

1.18 million trail users,[49] this means that the hiking trails in the Credit River Watershed provide recreational opportunities worth $3.2 million per year.

Parks and protected areas also provide great recreational opportunities. Within the Credit River Watershed there are a number of conservation areas, owned by CVC, as well as Forks of the Credit Provincial Park. In Great Britain, some research has examined the benefit of maintaining access to parks that are similar in size and location to urban centres as some of the parks in the Credit River Watershed. Transferring these benefits to the Credit suggested that recreational opportunities provided by the parks in the watershed are worth $36.44 per visitor per year, for a total of $1.4 million dollars per year based solely on the number of visitors to CVC's Island Lake, Belfountain and Terra Cotta conservation areas.

Of course the most accessible recreational opportunities are those provided by urban forests and green spaces. A study from Finland has examined the willingness of urban forest users to pay for six different urban forests. Taking an average of those six values, willingness to pay for urban forest recreation in the Credit River Watershed was estimated to be $18.50 per visitor per year.[50] When applied to the number of urban households, the urban forest in the Credit River Watershed provides recreational benefits of $1.0 million per year.

In total, recreational opportunities were estimated to provide benefits in the order of $13.6 million per year.

4.1.9 Amenity and Cultural

Natural and semi-natural areas are often highly valued for their scenic vistas or for their cultural significance. The Credit River Watershed is one with a large urban population base (in the south) immediately adjacent to a mosaic of agricultural and forest landscapes (in the north). This provides perfect conditions for generating significant amenity and cultural value. Many watershed residents enjoy scenic drives in the countryside and visiting local farms for activities like strawberry or apple picking. In New Brunswick, a study estimating the cultural benefits of preserving a similar amount of farmland as exists in the Credit River Watershed, found that people in New Brunswick were willing to pay $0.90 per household per thousand hectares to preserve agricultural land.[51] However, not everyone in the population holds amenity and cultural values for agricultural landscapes. Therefore, to transfer the New Brunswick value to the Credit River Watershed, the number of watershed residents that hold these values was needed. While getting specific data for the Credit River Watershed would require a separate survey, which was unfeasible for this study, some previous research examined this issue in the Niagara region of

---

[49] The number of trail users in the Credit River Watershed was estimated by multiplying the estimated population of the watershed (757,600) by the proportion of Ontarians who engage in hiking (16.8%, from *The Importance of Nature to Canadians*) and by the average number hiking trips per year (9.3, from *The Importance of Nature to Canadians*) for a total of 1.18 million trail users per year.

[50] It should be noted that the willingness to pay for urban forest recreation is much higher than for hiking. While it is difficult to account for the exact difference between the willingness to pay values, it is reasonable to assume that urban forest recreation would be valued higher than rural forest recreation. This difference is because urban forest recreation is much more accessible, requiring lower travel costs to engage in the opportunity, which results in a larger difference between what one would be willing to pay and what is actually paid.

[51] J. M. Bowker and D. D. Didychuk, "Estimation of the Nonmarket Benefits of Agricultural Land Retention in Eastern Canada," *Agricultural and Resource Economics Review* 23 (1994): 218–25.

Southern Ontario, estimating that 44% of the population held cultural values towards agricultural landscapes.[52] Assuming this holds for the Credit River Watershed, agricultural landscapes in the watershed provide benefits to residents in the order of $2.97 million per year.

Within the urban centres many people seek to own property close to natural and semi-natural area. One study in Finland examined how urban residents valued their urban forests by estimating their willingness to pay to prevent the development of existing urban forest.[53,54] This is an issue particularly relevant to urban portions of the Credit River Watershed. Applying the value of $50.19 per household per year[55] to the number of urban households in Credit River Watershed implies that those urban residents place a value on the urban forest in the order of $6.29 million per year.

4.1.10 Bundled Riparian Services

The nature of this type of research often makes it difficult to find studies that estimate one particular ecological service.[56] In the case of the ecological services provided by riparian areas, one study conducted in North Carolina estimated the value of five services together: waste treatment, water purification, soil retention, habitat and recreation. This study found that residents were willing to pay $46.16 per year to improve these services by increasing riparian forest. Applying this to the population of the Credit River Watershed resulted in an estimate of $34.97 million per year.

4.2 Value of Natural Capital Flows by Land Cover Type

The minimum value of natural capital flows for each of the land cover types assessed in this study varied significantly. Similar to the Greenbelt study, wetlands were estimated to have the highest value compared to other land covers in the Credit River Watershed, providing an estimated $187 million per year. Forests represented by the upland forest land cover and the riparian forest land cover provided $71 and $51 million in annual services, respectively. Table 5 presents estimates for each land cover type assessed in this report. Value estimates are provided on a per capita and an annual basis.

---

[52] Peter Prins, *Group Preferences for Rural Amenities and Farmland Preservation in the Niagara Fruit Belt* (Master's Thesis, University of Waterloo, 2005).

[53] L. Tyrvainen, "The Economic Valuation of Urban Forest Benefits in Finland," *Journal of Environmental Management* 62 (2001): 75–92.

[54] An alternative and more popular method used to estimate the amenity value of urban forest is the hedonic pricing method. However, in order to apply these values to the Credit River Watershed and maintain our transfer rules, we would have had to estimate the number of properties adjacent to the urban forest land, which was not possible given time and financial constraints.

[55] The value of $50.19 (2007 CAD) per household per year was an average of four willingness to pay estimates reported for four different urban forests in Finland. See L. Tyrvainen, "The Economic Valuation of Urban Forest Benefits in Finland," *Journal of Environmental Management,* 62 (2001): 75–92.

[56] In fact, summing the willingness to pay for a number of individual ecological services to estimate the total value of all ecological goods and services has been criticized because the summed value is likely to be more than what the population would be willing to pay for all the services. This issue is one that environmental valuation practitioners must deal with, and bundling services together is one way to do so.

It should be noted that natural capital values were, for the most part, calculated based on ecological services provided by the watershed, and these values were attributed to land covers based on which land covers typically provide the specific service.

Table 5. Value of natural capital by land cover type in the Credit River Watershed (2007 $CAD)

Land cover	Average value per capita per year ($)	Total annual value ($ millions)*
Water	19	14.5
Upland Forest	94	70.9
Riparian Forest	67	51.0
Urban Forest	25	18.7
Wetland	247	186.8
Meadows	10	7.8
Agriculture	28	21.4
Watershed Total	**490**	**371.1**

* These values should be considered a minimum lower bound of the natural capital value for the reasons outlined in section 3.5.

The results of the land cover valuation suggests that significant gains to natural capital can be achieved through an increase in forests, particularly upland and riparian forests. This information will be important for CVC when discussing proposed planning objectives in the coming years. It is discussed further in the chapter 6.

In Table 6 we provide estimates of ecological services by land cover type in the Credit River Watershed.

Table 6. Value of natural capital flows in the Credit River Watershed ($ millions 2007 CAD)

Ecological Service	Water	Upland Forest	Riparian Forest	Urban Forest	Wetland	Meadows	Agriculture	Total*
Climate Regulation		11.4	2.8	2.0	8.3	4.9	11.7	41.0
Gas Regulation		4.2	1.0	0.7				5.9
Disturbance Avoidance		0.1			16.0			16.1
Water Supply	4.8	49.0	12.0	8.5	26.2			100.5
Waste Treatment	1.6				135.5			137.1
Pollination		0.8	0.2	0.1		0.7	2.2	4.0
Habitat		1.6			0.9	1.5	4.6	8.6
Recreation	8.1	3.8		1.0		0.7		13.6
Amenity & Cultural				6.3			3.0	9.3
Bundled Riparian Services			35.0					35.0
Total	**14.5**	**70.9**	**51.0**	**18.7**	**186.8**	**7.8**	**21.4**	**371.1**

Note: These values should be considered a minimum lower bound of the natural capital value for the reasons outlined in section 3.5. Blank cells highlight ecological service–land cover combinations that were not estimated because of data limitations.

4.3 Natural Capital Stock Value by Land Cover Type

To put annual flow values into context, assume that you wanted to invest some money today in order to generate a flow of benefits worth $371 million per year indefinitely. How much money would have to be invested today? It would depend on the interest rate. Assuming a 2% interest rate, you would need to invest $18.6 billion today to provide an indefinite flow of value worth $371 million per year. At a 5% interest rate, you would need $7.4 billion. This capitalized value can be thought of as the natural capital value and, as mentioned previously, is derived from the flow of ecosystem service values provided by the natural capital assets (i.e., natural land cover).

Table 7 reports estimates of the natural capital stock value based on a both a 2% and a 5% assumed discount rate. This table also highlights the affect of changing the assumed indefinite flow of benefits to a 10-year flow of benefits. As calculated, the natural capital stock value ranges from $2.9 billion to $18.6 billion.

Table 7. Natural capital stock value estimates in the Credit River Watershed ($CAD millions).

	Water	Upland Forest	Riparian Forest	Urban Forest	Wetland	Meadows	Agriculture	Watershed Total
Annual Flow Value	14.5	70.9	57.0	18.7	186.8	7.8	21.4	371.1
Natural Capital Stock Value of Ecological Service Flows in Perpetuity								
2% Discount	725	3,545	2,850	935	9,340	390	1,070	18,555
5% Discount	290	1,418	1,140	374	3,736	156	428	7,422
Natural Capital Stock Value of Ecological Service Flows for the Next 10 Years								
2% Discount	130	637	512	168	1,678	70	192	3,333
5% Discount	112	547	440	144	1,442	60	165	2,866

4.4 Value of Natural Capital Flows by Subwatershed

Each subwatershed in the Credit River Watershed is composed of a mosaic of land cover types with a unique composition of ecological service values. The estimated minimum natural capital flow value was attributed to each subwatersheds based on the average value per hectare for each land cover.

Figure 9 illustrates natural capital values by subwatershed. It is clear from this figure that subwatersheds in the north and northwest contain the highest value of natural capital. This pattern results from the large concentration of wetlands, which were considered the most valuable land cover, in those subwatersheds. In the south, where land use is dominantly urban, values are much lower. However, it should be noted that subwatershed values *were allocated based on the average natural capital values for each land cover and therefore do not reflect the relative scarcity of land cover*. Therefore, interpretation of these results should be done with care.

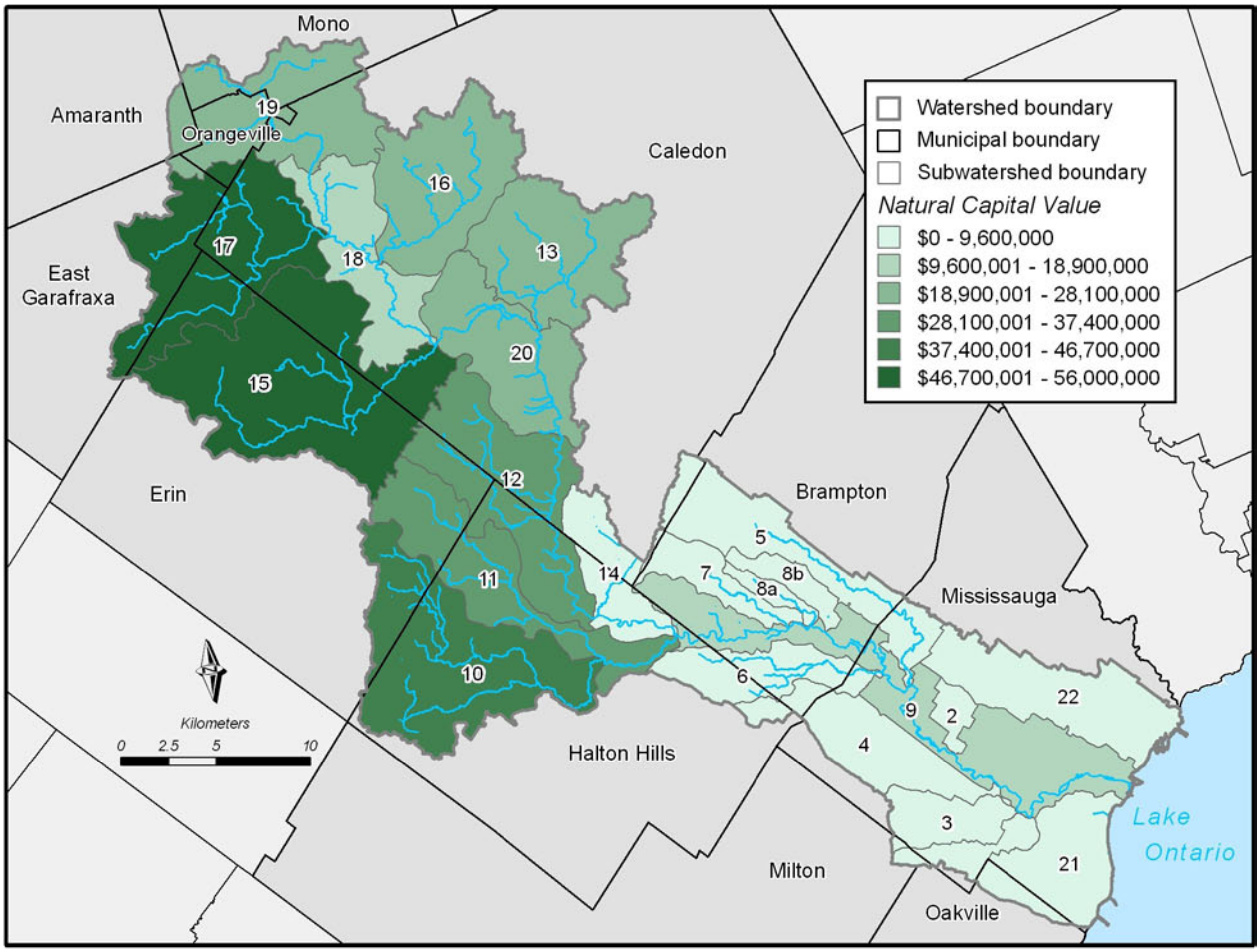


Figure 9. Value of natural capital by subwatershed in the Credit River Watershed

Source: Credit River Conservation 2008

Key Message

In Figure 9, the southern portion of the watershed lacks natural capital and consequently has a low natural capital value. However, the marginal benefit from one hectare of additional natural capital in this region would be much more significant than in the north. By implication, restoration and rehabilitation of natural features in the lower portion of the watershed could provide the greatest improvements in the natural capital value of the whole watershed.

5. Scenario Analysis

The natural capital valuation, detailed above, demonstrates that the natural environment has significant value. However, since land-use decisions are made on the margin, natural capital value, as it is presented above, is not overly useful from a decision making standpoint. In this chapter we demonstrate, through two case studies, how natural capital valuation on a watershed scale could be used to inform decision making in a more functional way.

5.1 Future Land-Use Change Scenarios

To demonstrate the application of natural capital valuation to patterns of land-use change we drew upon two key land management issues faced by CVC. In particular, we explore potential threats of continuing urban sprawl on the Credit's natural capital, and on the positive side, the efforts of CVC to invest in natural capital through restoration. While the scenarios are simple constructs of much more complex policy issues, they also represent the realities facing Conservation Authorities in Ontario, Provincial Governments and the Canadian Federal Government.

5.1.1 Scenario 1: Urban Development

As mentioned earlier, relentless pressure to develop land surrounding urban areas within the watershed is one of the most significant threats to the watershed's environmental health. Decisions to develop marginal urban lands generally do not consider the full cost of development (e.g., the cost of lost natural capital). As a result, development projects that may not have had their full cost considered, go ahead. The case of natural and semi-natural land conversion to urban or other developed land cover, is one where natural capital valuation has potential to provide more complete information on development costs.

A recent study conducted by CVC examined the implications of future land development scenarios on the health of the watershed.[57] This work demonstrated the danger that business-as-usual urban development could have on the health of the Credit River Watershed. It defined potential future urban development scenarios that would see the amount of urban land increase from 15% to 25% of the watershed.[58] In simple terms, land-use changes associated with this potential urban development implies the conversion of 1,065 ha of upland forest, 206 ha of riparian forest, 466 ha of wetlands, 1,068 ha of meadows and 7,198 ha of agricultural land to urban cover, as illustrated in Figure 10. It is recognized that current land-use polices and practices would restrict this conversion to some extent. This analysis is provided for illustrative purposes only.

---

[57] CVC, *Credit River Water Management Strategy Update*. (Mississauga, ON: Credit Valley Conservation, 2007).

[58] It should be noted that our numbers for current developed land cover are much higher (33% of the watershed) because our figures include all subwatersheds and the two management areas (21 and 22) shown in the subwatershed map (Figure 2), while the Management Strategy Update focused only on the subwatersheds.

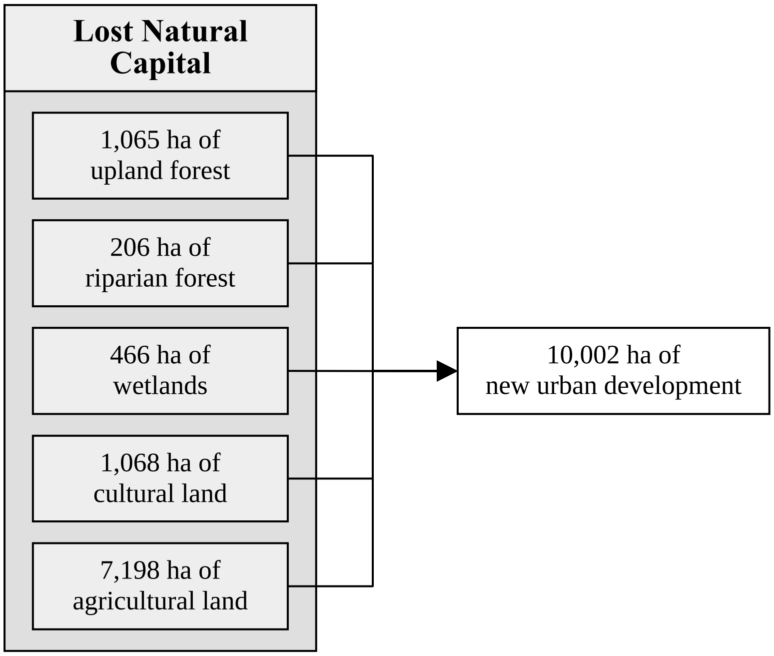


Figure 10. Illustration of how the urban development scenario was measured

5.1.2 Scenario 2: Reforestation and Naturalization

One of CVC's mandates is restoration of degraded and damaged ecosystems, of which reforestation and naturalization are key components. In 2007 CVC articulated a 10-year capital plan, in which massive reforestation and naturalization goals were set. By 2017, CVC expects to plant 2.5 million seedlings (reforestation) and 317,000 trees and shrubs (naturalization), depending on sustained funding for these initiatives.

Reforestation and naturalization directly address potential pressures of climate change. More forest means more carbon sequestered and stored, which helps mitigate climate change. As well, more forest helps protect watercourses (improving water quality) and creates corridors that counteract fragmentation of natural cover. Understanding the value of these benefits could justify large upfront costs and help insure necessary funding required, allowing for continued investment in future natural capital.

In order to put this information into a land-use change context the following steps were taken (and illustrated in Figure 11):

- If the area of forest land increases, the area of other land cover must decrease. Since these CVC's plantings are typically done in under-utilized agricultural land and meadows, it was assumed that the forest area would increase at the expense of the two land covers.
- Due to lack of data it was assumed that planting would be divided proportionally between the two land covers (agricultural and meadows) based on total area of each land cover.
- The forest area that 2.5 million seedlings create was estimated to be 1,250 ha based on the assumption that 2,000 seedlings can be planted per hectare.[59] This was all attributed to upland forest.

[59] Z. Kovacs, personal communication, Credit Valley Conservation, October 17, 2008.

- The forest area that 317,000 trees and shrubs create was estimated to be 423 ha based on the assumption that 750 units can be planted per hectare.[60] Naturalization efforts are geared toward urban and riparian areas, therefore, it was assumed these plantings would convert under-utilized agricultural land and meadows to urban and riparian forest cover. In reality naturalization activities are done on private property in partnership with willing landowners. As a result, the location of naturalization projects tends to be opportunistic. Therefore, splitting the 423 ha of new forest into urban and riparian categories was done by the proportion of historical work done in these areas.
- While the success rate is always a concern for restoration and naturalization efforts, generally greater than 70% of the planted units survive.[61] As well it is likely — though not always — that the 30% mortality would be randomly distributed throughout the planted area. Given the scale of analysis considered here, it was assumed that mortality would not impact the total area converted to forest.

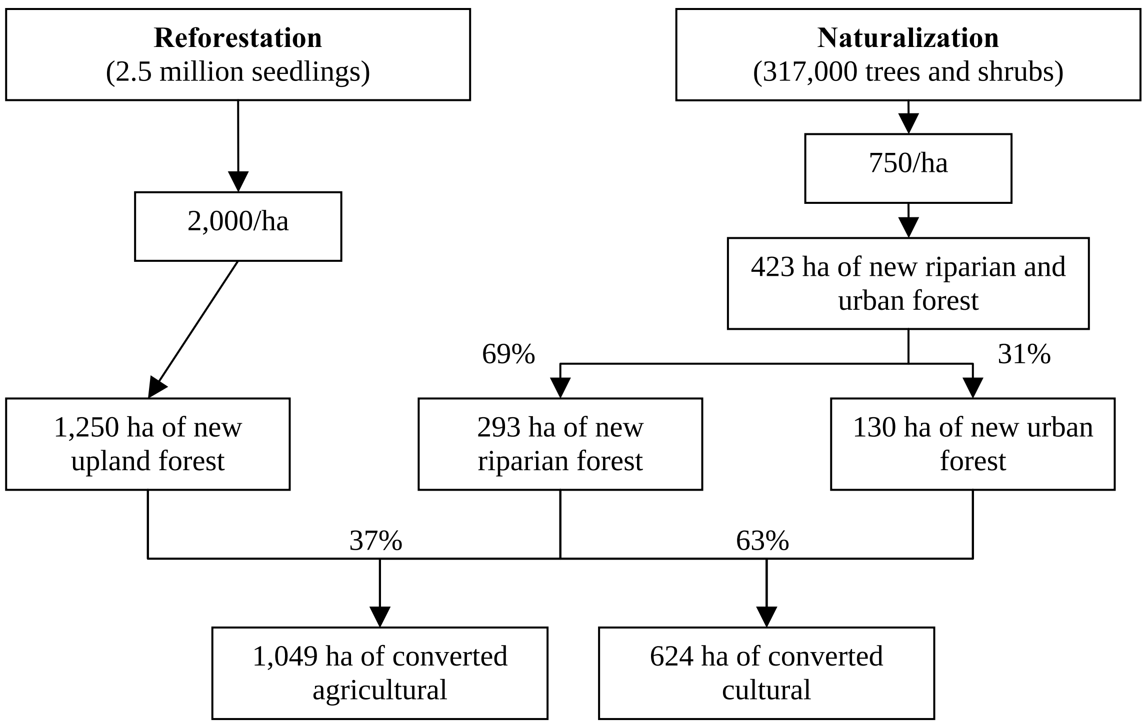


Figure 11. Illustration of how the reforestation and naturalization scenario was measured

5.2 Results of the Scenario Analysis

Once the land-use change was characterized, estimating the change in natural capital value became a matter of applying the average value per hectare for each land cover and ecological service combination to the change in area for each land cover. Table 8 summarizes gains and losses in natural capital value for each land cover by scenario.

---

[60] Z. Kovacs, personal communication, Credit Valley Conservation, October 17, 2008.

[61] Ibid.

Table 8. Change in natural capital flow values as result of urban development and reforestation land-use change scenarios.

	Change in Annual Natural Capital Value (2007 $CAD millions)	
Land cover	**Scenario 1: Urban Development**	**Scenario 2: Reforestation and Naturalization**
Water	0	0
Upland Forest	-6.5	7.6
Riparian Forest	-3.9	5.5
Urban Forest	0	1.3
Wetland	-14.8	0
Meadows	-0.8	-0.7
Agriculture	-4.9	-0.4
Developed	0	0
Total	**-30.8**	**13.2**

Similar to Table 6 in section 4.3, the change in flow of benefits provided to the watershed under the two land-use change scenarios has ramifications for natural capital stock values in the watershed. Table 9 presents changes in stock value under the two land-use change scenarios.

Table 9. Change in the natural capital stock value as result of urban development and reforestation land-use change scenarios ($ millions 2007 CAD).

		Change in Capital Value (in perpetuity)		Change in Capital Value (over 10 year)	
Scenario	**Change in Flow Value**	2% Discount	5% Discount	2% Discount	5% Discount
Urban Development	-30.8	-1,540	-616	-277	-238
Reforestation / Naturalization	13.2	660	264	119	102

5.2.1 Scenario 1: Urban Development

The results presented in Table 8 suggest that converting 10,000 ha of natural and semi-natural land to urban cover would cause the value of ecological services to decline by $30.8 million per year. This means that if urban development continues business as usual, with 25% of the watershed urbanized, the annual value of the watershed's natural capital would reduce by 8%. However, using this method to estimate the change in value implicitly assumed the value of ecological services provided by the river itself (water land cover) would not be impaired by urbanization. This assumption is unrealistic, because research shows that urbanization significantly affects river quality. Consequently, the estimated lost natural capital value is significantly undervalued.

5.2.2 Scenario 2: Reforestation and Naturalization

As shown in Table 8, the increase in natural capital value that would be provided by new forest cover is almost $13.2 million per year. However, this is the value of mature forest communities. In reality a landscape planted for reforestation purposes will take decades of growth and proper management to reach this stage. This means that the natural capital value of a planted landscape will slowly increase as the forest slowly matures providing more and higher quality ecological services. However, to put this issue into perspective a recent study found that, restored eastern North American temperate forest generates 88% of native forest ecological service value, within 10 years.[62]

Cost estimates produced by CVC indicate that on average reforestation and naturalization activities cost $3,000 per hectare and $12,750 per hectare, respectively. Applying these cost estimates to the expected plantings for the next 10 years resulted in a total cost of $8.4 million. The actual outlay of $8.4 million would be distributed over the 10-year period depending on the actual number hectares planted each year.

If restored forest can provide 88% of ecological services values within 10 years, then those trees planted in the first year of planting will be producing significant value at the end of the planning period. Trees planted in the last (10th) year would provide significant value 20 years from the beginning of the planning period. To compare benefits to costs we made the conservative assumption that ecological service values from the planted forest is zero for the first 20 years at which point 88% of the $13.2 million in annual benefits begins. This stream of benefits results in a present value of $391 million (2% discount rate).[63] Even without discounting the flow of costs, it is clear that reforestation and naturalization are justifiable from CVC's perspective. However, a proper cost benefit analysis would incorporate the opportunity cost of reforested land, which could be significant depending on the planted land's proximity to urban development pressures. That being said, actual plantings have often been, and will likely continue to be, located in more rural areas suggesting that opportunity costs may not be overly significant for these planting initiatives.

5.3 Limitations of the Scenario Analysis

The scenario analysis demonstrates how we might begin to use natural capital estimation to inform policy decisions. However, a number of issues remain that limit the usefulness the approach taken here.

---

[62] Walter K. Dodds, Kymberly C. Wilson, Ryan L. Rehmeier, G. Layne Knight, Shelly Wiggam, Jeffrey A. Falke, Harmony J. Dalgleish and Katie N. Bertrand, "Comparing Ecosystem Goods and Services Provided by Restored and Native Lands," *BioScience* 58, no. 9 (2008): 837–45.

[63] It should be noted that because the change in value was estimated using the average value (not the marginal value), the flow of increased benefits will be overestimated. However, this concern is likely offset by the fact that the benefits themselves (from which the average value was calculated) were significantly underestimated.

Given time and resource constraints, conducting the scenario analysis required the application of average per hectare values to changes in area for each land cover type. This approach implies a linear relationship between quantity of each land cover and its natural capital value, which is an over simplification. As with all resources, as the amount of natural capital decreases, its relative value would increase as a result of increased scarcity.

It should also be kept in mind that, due to limited data availability, not all ecological services were able to be accounted for, suggesting that total natural capital is undervalued in chapter 4. As a result, examining the difference in natural capital value between two land covers could be skewed if comparing the difference between a land cover that had many ecological services valued with one that had few valued.

In the urban development scenario, it should be noted that some current and future policies would prevent the intensity of development we have modelled. For example, the scenario considered urban development to the stream bank as well as conversion of many wetlands. Existing policies limit this type of development. Taking these issues into consideration would lower the cost of urban development.

Finally, the scenario analysis only focused on changes in quantity. Because changes in quality of ecological services are also a key component of natural capital value, future work needs to explore how to incorporate quality.

6. Discussion, Recommendations and Conclusions

6.1 Summary

The Credit River Watershed is endowed with tremendous natural wealth; an endowment that current development pressures are placing in jeopardy. Through the analysis conducted for this report we found that the Credit River Watershed's natural capital provides a *minimum* annual flow of ecological services valued at $371 million. This is a flow of value that provides at least $490 per year to each resident in the watershed. It would take an investment of $18.5 billion at 2% to provide this cash flow.

The analysis conducted for this report highlights that wetlands, forests, agriculture and water are particularly important for maintaining and enhancing the value of natural assets in a watershed like the Credit. These land cover types provide value in the order of $187 million per year, $141 million per year, $21 million and $14 million per year to residents of the watershed, respectively.

Some of the key ecological services provided to residents of the Credit River Watershed include the following:

- Waste treatment, valued at $137 million/year
- Water supply, valued at $100 million/year
- Climate regulation, valued at $41 million/year
- Bundled riparian services, valued at $35 million/year[64]

Recently two natural capital studies have been released which were conducted within Southern Ontario: "Ontario's Wealth Canada's Future: Appreciating the Value of the Greenbelts Eco-services" and "Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services." In our assessment of the Credit River Watershed we used a similar natural capital valuation framework. However, access to biophysical data allowed much more detailed methods of transferring and applying values. Table 10 compares results of the three studies.

[64] The bundled services include waste assimilation, water purification, soil retention, wildlife habitat and recreation.

Table 10: Comparison of natural capital valuations in Southern Ontario

	Credit River Watershed	Lake Simcoe Watershed	Ontario's Greenbelt
Study Site Area	94,885 ha	330,700 ha	760,420 ha
Total Annual Natural Capital Value	$371.1 million	$975 million	$2,600 million
Average Natural Capital Value (per hectare per year)	$3,911	$2,948	$3,487
Population	757,600	350,000	NA
Average Natural Capital Value (per capita per year)	$490	$2,780	NA

As shown in Table 10, our total annual value is much lower than the other two studies, due in part by the fact that the Credit River Watershed, covers a much smaller area of land. However, on a per hectare basis, our results are similar to the previous studies, in particular the Greenbelt study. Given the slightly different approaches, the similarity of these results provides credibility to all three studies. The apparent difference between the Credit River and Lake Simcoe watershed average per hectare values makes sense because the Credit is a much higher populated region meaning there are more people who would be willing to pay. This is also why there is such a drastic difference in the average values per capita.

Previous research that conducted environmental valuation in a fashion similar to this study has been criticized for suggesting the value of the world's ecological services exceeds the world's income.[65] Because economic value is based on what individuals are willing to forgo (often measured by willingness to pay) in order to maintain ecological services, one cannot forgo more then they have. In order to assess the reasonableness of our estimates we compared the value of natural capital to the income of watershed residents. With 242,695 watershed households[66] the natural capital value averages out to be $1,529 per household per year. Since the watersheds average 2005 after-tax household income was $73,321, the annual natural capital value accounts for only 2.1% of the watersheds annual after-tax income, a reasonable and conservative estimate, lending additional credibility to the results.

The scenario analysis provided insight into how natural capital could be influenced by future development paths faced by the watershed. If current trends in urban development persist we can expect to see a reduction in natural capital. In the urban development scenario examined in chapter 4, the development pattern leading to 25% of the watershed being developed would decrease the value of natural capital by $30 million per year.

Conversely, the reforestation and naturalization scenario, which is expected to cost the Conservation Authority $8 million over 10 years, is expected to increase the value of natural capital by $13.2 million annually.

---

[65] Costanza et al., "The value of the world's ecosystem services and natural capital," *Ecological Economics* 25 (1998): 3–5.

[66] As per Statistics Canada's 2006 census of the population.

Given the threats to the Credit River Watershed identified in this report (section 2.4), enhancing the capacity of the landscape to sustain ecological services can help address many of these stressors. Arguably, climate change is the most severe threat facing humanity, and conserving natural capital will not only enable us to sequester and store climate-altering CO_2 but also enhance nature's resiliency to climate events. Over the long term, this conservation will enhance the watershed's adaptability and reduce the risk of exposure to costly impacts of a changing climate.

Further work is needed to develop a more comprehensive set of models that will enable further linkages between biological and economic impacts of land-use planning and resource-use decisions; however this work serves as a first step towards that goal.

6.2 Recommendations

Based on research and analysis conducted for this report, there are a number of research and policy recommendations that should be addressed in future work on natural capital and ecological services.

6.2.1 Research Recommendations

Through the course of this work a number of research-related recommendations emerged that should be addressed in future work on natural capital valuation.

- Criteria and protocols for conducting benefits transfer estimations should be reviewed for implications on the accuracy and legitimacy of natural capital estimates.
- Currently, there is a shortage of valuation studies in Canada, by eco-region. If economic valuation is to be used more frequently in policy analysis and planning, a larger database of primary valuation studies is needed within the Canadian context.
- Further research on the range of ecological service indicators is needed to provide practitioners and policymakers with greater clarity around the quantity and quality of ecological services within specific landscape types.
- Further research is needed to make concrete linkages between levels of ecological service provision and human wellbeing. In addition, research into effective communication strategies would benefit many policymakers and practitioners to better articulate the importance of restoring, maintaining and improving current levels of ecological services.

6.2.2 Policy Recommendations

For governments to effectively manage ecosystems in a manner that provides the greatest amount of benefit to society we recommend the following:

Strong leadership

Government leaders at the federal, provincial and municipal level have a very important role to play in ensuring that this country and the watersheds where people reside are sustained for current and future generations. The investments made today in nature can reap real gains for current populations, as demonstrated by the analysis conducted in this report. Further, investment in natural capital today can provide future generations with the security of having quality of life as good or better than our own. All levels of government have the opportunity to provide strong leadership through:

- Investing in a robust framework for measuring and tracking natural capital
- Investing in natural capital
- Investing in education and awareness
- Incentives for conservation of ecological services

Investing in a robust framework for measuring and tracking natural capital

Before much more time and effort is invested in assessing natural capital in various regions of Canada, we need to adopt a framework for natural capital accounting that links flows of benefits from natural capital through ecological services with the market economy. Current natural capital assessments have served primarily as education and awareness building exercises. The reason for this is two-fold. The first reason is that education and awareness is important as we increase our understanding of the social and economic benefits of ecological services. Secondly, and more importantly, many organizations and government departments lack resources to undertake adequate accounting, monitoring and assessment of the impacts the market economy has on natural capital. As populations grow and urbanization increases, scarcity of the environment will become more pronounced. To begin to adequately conduct trade-offs of investments in nature or investments in more urban sprawl, we need to consider what we are giving up. To do this we need to develop, test and implement a comprehensive natural capital accounting framework that serves as a biological-economic model with clear linkages between economic flows and biological flows.

Investing in natural capital

To date Canada’s investment in natural capital has occurred mainly from increased political pressure from stakeholders and the general public. In our current economic thinking we often consider investments in nature to be frivolous. During difficult economic times (like the present) the tendency is to cut environmental expenditures, but what we often fail to see is that investments in natural capital can have clear benefits to the market economy and more importantly to human well-being. Currently, there exist a wide range of examples of market and non-market based policy instruments governments can use to finance the restoration, maintenance and further provisioning of ecological services. New types of policy instruments should be explored for their ability to supplement existing provincial and federal conservation strategies.

Investing in education and awareness

The role that ecological services play in our lives generally lies beneath the surface of that which we see, feel and touch. We, as a society, take for granted many of the life-sustaining benefits accrued from a healthy and functioning ecosystem. Because of this, the importance of natural capital is often overlooked. Governments need to further invest in building awareness in all demographic groups to better understand, appreciate and maintain natural capital. Further, once the importance of natural capital becomes apparent we will then seek to improve it. First, we need to make people aware of its importance in our day-to-day lives.

Incentives for conservation of ecological services

Around the world governments, community organizations and non-profit organizations are demonstrating that market-based approaches to conserving ecological services can be an effective approach to integrating economic benefits with environmental outcomes. Through tradable permit schemes, environmental taxes, payment for ecological service programs, among others, governments can raise the necessary dollars needed to enhancing existing ecological service functions.

6.3 Conclusions

This study has clearly demonstrated that economic value is associated with natural heritage features and functions within the Credit River Watershed. We rely on nature to sustain the quality of life we enjoy today and will enjoy into the future. Land-use decisions, more often than not, have a negative impact on the natural capital that sustains us. Valuing natural capital can be an effective tool for decision-makers who are trying to determine the most efficient way to restore and conserve the natural environment.

There is significant economic benefit to investing in natural capital. This can be done in a number of ways. Directly, we can expand conservation areas, parks and green spaces. We can reclaim abandoned lands (industrial and agricultural) to rejuvenate these sites back into thriving forests. Further, we can also expand our thinking in terms of urban design and planning to incorporate more natural features, which provide a wide range of economically important goods and services.

Appendix: Overview of Natural Capital

Natural Capital and Ecological Services

Natural capital is the *stock* of natural resources and environmental assets, such as forests, rivers and wetlands, that exist in a region at a given point in time. Over time, this natural capital stock yields a *flow* of ecological services, such as oil, minerals, water filtration and carbon sequestration.[67]

Ecological services, which provide value to humans, are a direct result of ecosystem composition, structure and function. This means that the variety of elements, the physical and biological components, and the complex interactions between the various organisms and the physical environment in an ecosystem combine to provide goods and services that humans use everyday. For example, the composition, structure and function of a healthy wetland ecosystem can provide water purification, flood control and groundwater recharge services, all of which provide value to humans. Table 11 outlines a number of ecosystem functions, processes and services.

Table 11: Ecosystem function, processes and resulting ecological services

Ecosystem Function	Ecosystem Process	Ecological Services
Water regulation	Role of land cover in regulating runoff and river discharge	Provides natural irrigation, drainage, channel flow regulation and navigable transportation
Water supply	Filtering, retention and storage of fresh water (e.g., in aquifers)	Provides water (quality and quantity) for consumptive uses (e.g., drinking and irrigation)
Gas regulation	Role of ecosystems in bio-geochemical cycles	Provides clean, breathable air, disease prevention and a habitable planet
Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of a favourable climate promotes human health, crop productivity, recreation and other services
Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances	Prevention or mitigation of natural hazards generally associated with storms or other severe weather (e.g., flood risk reduction)

[67] Robert Costanza, Ralph d'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert O'Neill, Jose Paruelo, Robert Raskin, Paul Sutton and Marjan van den Belt, "The value of the world's ecosystem services and natural capital," *Nature* 387 (1997): 253–60.

Ecosystem Function	Ecosystem Process	Ecological Services
Soil retention	Role of vegetation root matrix and soil biota in soil retention	Maintenance of arable land; Prevention of damage from erosion
Soil formation	Weathering of rock, accumulation of organic matter	Maintains agricultural productivity and the integrity of natural soils
Nutrient regulation	Role of biota in storage and re-cycling of nutrients	Promotes health and productive soils, and gas, climate and water regulations
Waste treatment	Role of vegetation & biota in removal or breakdown of xenic nutrients and compounds	Pollution control/detoxification; Filtering of dust particles; Reduction of noise pollution
Pollination	Role of biota in movement of floral gametes	Pollination of wild plant species and harvested crops
Biological control	Population control through trophic-dynamic relations	Provides pest and disease control, reduces crop damage
Habitat	Role of biodiversity to provide suitable living and reproductive space	Biological and genetic diversity, habitat for migratory species
Food	Conversion of solar energy into edible plants and animals	Hunting, gathering of fish, game, fruits, etc.; small scale subsistence farming & aquaculture
Raw materials	Conversion of solar energy into biomass for human construction and other uses	Building and manufacturing; fuel and energy; fodder and fertilizer
Genetic resources	Genetic material and evolution in wild plants and animals	Improve crop resistance to pathogens & pests
Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota	Drugs, pharmaceuticals, chemical models, tools, test and essay organisms
Aesthetic information	Attractive landscape features	Enjoyment of scenery
Recreation	Variety in landscapes with (potential) recreational uses	Travel to natural ecosystems for eco-tourism, outdoor sports, etc.
Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc.
Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e., heritage value of natural ecosystems and features)

Source: Adapted from R. S. de Groot, M. A. Wilson and R. M. J. Boumans (2002), “A Typology of the Classification, Description and Valuation of Ecosystem Functions, Goods and Services,” *Ecological Economics,* 41 (3): 393–408.

Traditionally, the valuation of natural capital has focused on natural resources, such as timber, minerals and oil, that provide material well-being to humans. However, human well-being is influenced by more then material goods. In order to fully understand the social impacts of land-use change we must account for the contribution of non-market ecological services to human well-being. The role of natural capital (measured as the flow of ecological services) is depicted in Figure 12.

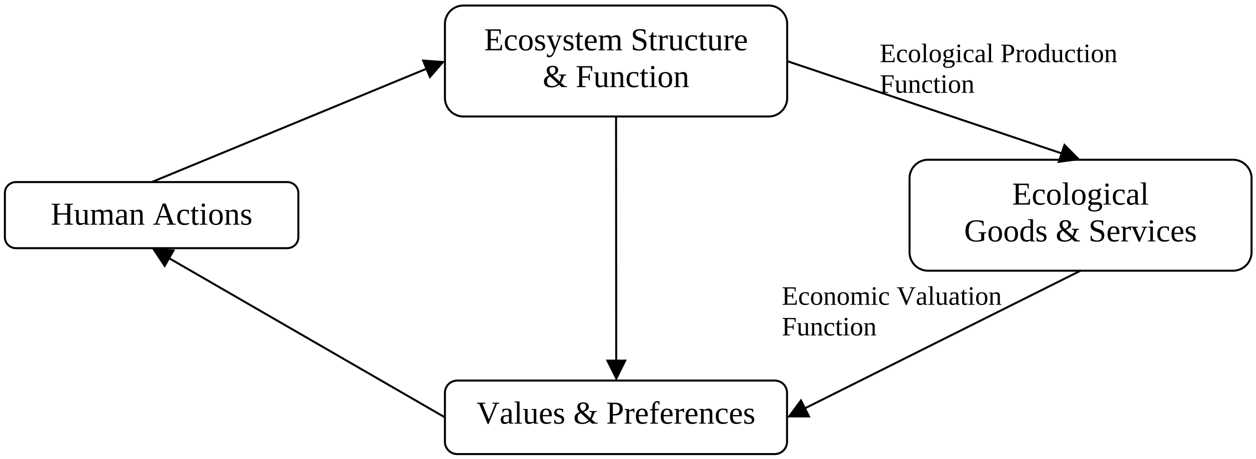


Figure 12. How ecosystem structure and function generate ecological services

Source: Adapted from National Research Council of the National Academies, "Valuing ecosystem services: Toward better environmental decision-making" (The National Academies Press, Washington, D.C., 2005), 37–38.

Figure 13 highlights the interconnectedness between the quality and quantity of our natural environment (ecological services), how we impact the natural environment (direct and indirect drivers) and how this ultimately influences human well-being. The linkage between ecological services and human well-being can be measured through valuing ecological services or natural capital valuation.[68] By assigning an economic value to the ecological services in a particular region we can get a measure of the value of a region's natural capital.

Importance of Natural Capital to Decision-Making

If the value of natural capital is not accounted for, we are implicitly assuming that these goods and services are worth nothing. Unfortunately, this has typically been the case in cost-benefit analysis. Cost-benefit analysis is the framework used by policy makers (a less formal form is used by businesses) to assess whether or not a project or policy should go ahead. As such, natural capital valuation enables us to begin to capture some of the value of these ecological services, which may serve to strengthen future policy making. Natural capital valuation can enhance decision-making by governments and non-government organizations by:[69]

1. Informing management and policy decisions when trade-offs exist and measuring the extent of these trade-offs.
2. Providing estimates for natural resource damage assessments to enable the equitable compensation, to society, for damages inflicted by unrestrained industrial production.
3. Providing guidance on where conservation dollars can be spent in an economically efficient manner- through valuation we can target key ecological services or stocks of services that might otherwise be lost.[70]

---

[68] These terms are often used interchangeably.

[69] National Research Council of the National Academies, *Valuing Ecosystem Services: Toward Better Environmental Decision-Making* (Washington, D.C.: The National Academies Press, 2005), 37–38.

[70] It is worth mentioning that this area is currently in development and further work is needed to incorporate this type of decision-making into policy and industrial planning.

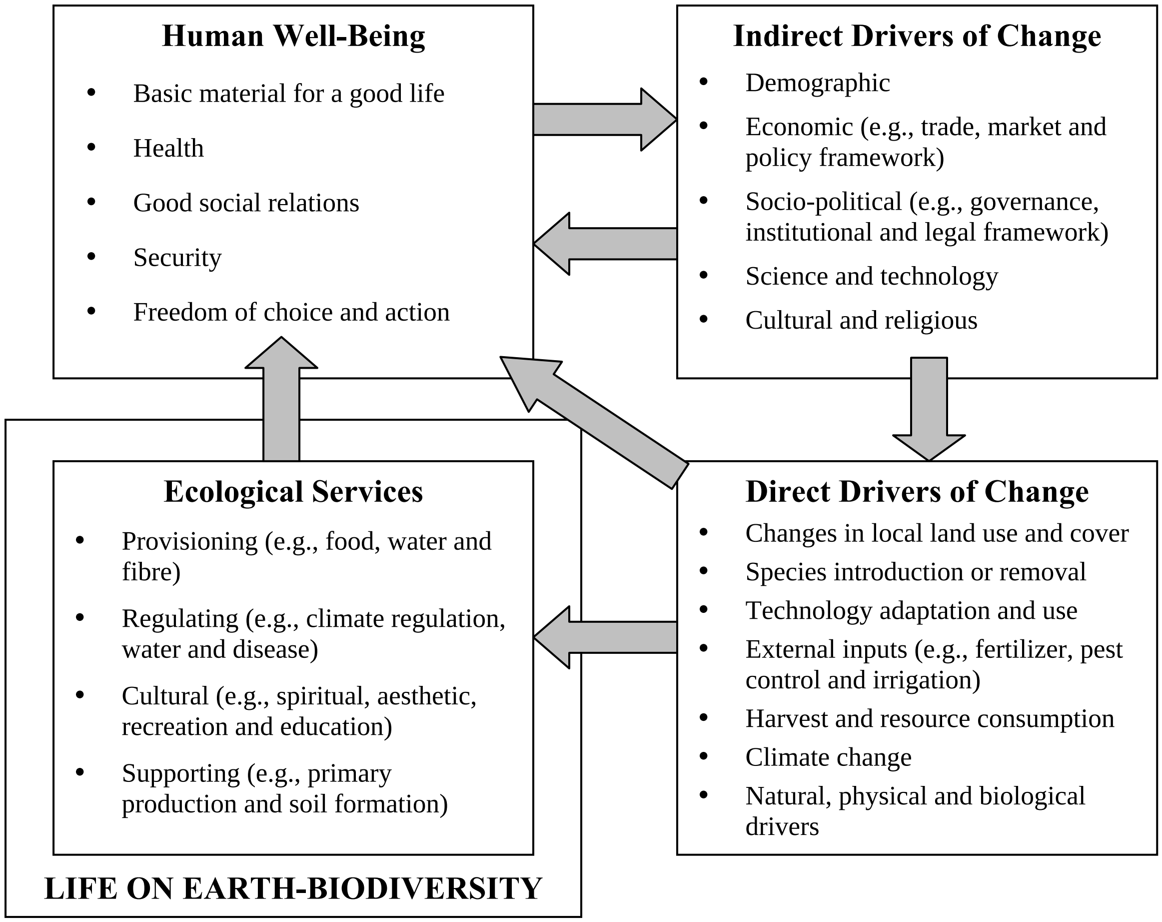


Figure 13. Millennium Ecosystem Assessment conceptual framework of interactions between biodiversity, ecological services, human well-being and drivers of change

Source: Adapted from Millennium Ecosystem Assessment 2005

Further, there are a number of benefits to valuing the full suite of natural capital assets. For example:

1. By valuing the natural capital we can gauge the efficiency with which we use our natural assets. It is in society's best interest to use our natural assets to their highest value. Without understanding the value of natural capital we risk allocating those assets to lower value uses.
2. Valuation of natural capital assets allows the value of a region's natural wealth to be compared with other forms of capital according to a common denominator (usually monetary).[71]
3. Natural capital can be depleted through over-use and exploitation.[72] By valuing the stock of natural capital we can estimate the impact environmental degradation has on the natural wealth of a region.

---

[71] Lucy Emerton and Elroy Bos, *Value: Counting Ecosystems as Water Infrastructure* (Gland, Switzerland: IUCN, 2004).

[72] Ducks Unlimited and Nature Conservancy Canada, *The Value of Natural Capital in Settled Areas of Canada,* prepared by Nancy Olewiler, Department of Economics and Public Policy, Simon Fraser University (2004).

4. By valuing the natural capital, the most cost-effective approach to enhancing natural capital (through management and conservation) can be identified with increased rigor. Valuation of natural capital allows the diagnosis to focus on the whole system rather than just individual parts of the system.[73] Economists refer to this as internalizing the unaccounted cost borne by the environment.
5. Natural capital assessments can provide a more accurate depiction of the importance of natural resources to a regional economy, thereby invoking a sense of stewardship.[74]
6. The rate at which natural resources are used and/or extracted can be more thoroughly assessed, thereby better articulating the line between over-exploitation and sustainable management.[75] This is particularly important when we measure the productivity of our industries. Natural capital is an input into many production processes in Canada and accurately accounting for the portion of natural capital as a proportion of total input capital provides us with a measure of natural subsidies to our industries.[76]
7. Natural capital assessments can feed into lifecycle cost accounting, thereby increasing the understanding of the entire cycle of costs and benefits related to various forms of capital.[77] Engineers and economists use lifecycle cost accounting to evaluate the environmental impacts of various products, processes and activities. Currently, without the incorporation of land-use change and land-use related impacts of particular activities current lifecycle accounting practices can understate total impacts of particular projects.[78]

Importance of Natural Capital to Commerce

To ensure that accounting for nature is not inadvertently deemed an “anti-business” approach we want to discuss briefly how businesses can harness the information that can be gathered through natural capital valuation. The benefit of natural capital valuation to businesses has been discussed in great detail in a landmark book entitled *Natural Capitalism* authored by Paul Hawken, Amory Lovins and L. Hunter Lovins.[79] The book envisions an industrial transformation that is beginning to occur. The book highlights that companies that take a long-term view by instituting innovative ways to use natural resources and ecological services to more efficiently

---

[73] John Loomis, “Use of non-market valuation studies in water resource management assessments” (Fort Collins, CO: Colorado State University, 2004).

[74] Daisy MacDonald, Nick Hanley and Ian Moffat, “Applying the concept of natural capital criticality to regional resource management,” *Ecological Economics* 29 (1999): 73–87.

[75] Tom Green, “Confusing liquidation with income in BC’s forests: economic analysis and the BC forest industry,” *Ecological Economics* 43 (2000): 33–46.

[76] Nancy Olewiler discusses this topic in more detail when she considers the measurement of natural capital as a necessary segregation from measures of total factor productivity. For more information, see Nancy Olewiler, “Natural Capital and Sustainability and Productivity: An exploration of linkages.”

[77] Angela Arpke and Kelly Strong, “A comparison of life cycle cost analyses for a typical college dormitory using subsidized versus full-cost pricing of water,” *Ecological Economics* 58 (2006): 66–78.

[78] Nandan Ukidwe and Bhavik Bakshi, “Flow of natural versus economic capital in industrial supply networks and its implications to sustainability,” *Environmental Science and Technology* 39, no. 24 (2005): 9759–69.

[79] Paul Hawken, Amory Lovins and L. Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution* (Snowmass, CO: Rocky Mountain Institute, 1999).

improve their bottom line. In general this book highlights four strategies that businesses could adopt, which would move them towards Natural Capitalism:[80]

- **Radical resource productivity** is a production process that slows depletion of natural inputs, lowers pollution and creates more jobs.
- **Biomimicry:** nature already possesses the processes, functions and products that can be used in industrial processes. Examples of some of these processes and products include the silk made by spiders, which is stronger than Kevlar and much tougher. Similarly, trees turn sunlight and water into a sugar (i.e., cellulose) that is tougher than nylon with a higher bending strength and stiffness than concrete or steel.
- **A service and flow economy** "involves shifting from a perception of wealth as goods and purchases to a perception of value as desired services and satisfaction of human needs."[81] This type of system is underpinned by the idea of "Reclaiming Consumption" a relatively new academic concept.

  "*Reclaiming consumption is a shift from sustainable consumption; it emphasizes getting maximum satisfaction over the long term from the dollars you spend. This may involve spending more for services than goods, and a preference for durable, high quality products that support a higher quality of life.*"[82]
- **Investing in Natural Capital** can involve developing markets for ecological goods and services, or investing in the enhancement and restoration of the environment. This is much of what is advocated in this report.
- **The role of businesses** as it relates to natural capital is gaining momentum. Many universities offer business majors with classes and programs in Corporate Social Responsibility (CSR). An increasing number of Canadian businesses are adopting and reporting on CSR activities in response to government encouragement.[83]

---

[80] The summary of *Natural Capitalism* is adapted from a review of the book by Steven Marx of California Polytechnic State University in San Luis Obispo, California, cla.calpoly.edu/~smarx/nature/natcap/natcap.html.

[81] Hawken, Lovins and Lovins, *Natural Capitalism*.

[82] Emily Huddart-Kennedy, personal communications, University of Alberta, September 4, 2008.

[83] Industry Canada, "Corporate Social Responsibility: CSR Initiatives by Industry" (Ottawa, ON: Government of Canada, 2005), www.ic.gc.ca/epic/site/csr-rse.nsf/en/h_rs00061e.html.