Catalogue no. 16-201-X

Human Activity and the Environment

Measuring ecosystem goods and services in Canada

2013

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Statistics Canada

Environment Accounts and Statistics Division

Human Activity and the Environment

Measuring ecosystem goods and services in Canada

2013

Published by authority of the Minister responsible for Statistics Canada

December 2013

Catalogue no. 16-201-X

ISSN 1923-6751

Frequency: Annual

Ottawa

Cette publication est également disponible en français.

Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

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Symbols

The following standard symbols are used in Statistics Canada publications:

.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0s	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
p	preliminary
r	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
E	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

Acknowledgements

Human Activity and the Environment 2013 was prepared by the Environment Accounts and Statistics Division under the direction of Robert Smith[1,2,3] (Director) and Carolyn Cahill[2] (Acting Director). François Soulard[1,2] was the project manager, Jennie Wang[1] was the editor and Michelle Tait managed production.

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Thanks to the following people and services for their support in the areas of conceptual and technical development, map creation, data tabulation and verification, translation and dissemination:

Neda Amralah
Mike Comeau
Hugo Larocque
Cindy Lecavalier
Soheil Rastan[1]
Jack Ruitenbeek
Dissemination Services
Translation and Terminology Services

We are indebted to those who have taken time to review and discuss this work. The following individuals provided input throughout the course of the MEGS project:

Zeba Ali (Fisheries and Oceans Canada), Judi Beck[2] (Natural Resources Canada), Barbara Best[1] (Fisheries and Oceans Canada), Stefanie Bowles[1,3] (Policy Horizons Canada), Daniel Burnett[1] (Natural Resources Canada), Chiew Chong[1] (Environment Canada), Jeff Dechka[1] (Natural Resources Canada), Cindy De Cuypere, Robert Elliott[2] (Fisheries and Oceans Canada), Jeff Fritzsche, ZuZu Gadallah (Environment Canada), Céo Gaudet[1,2] (Environment Canada), Martine Giangioppi (Fisheries and Oceans Canada), Marcelle Grenier[1,3] (Environment Canada), Ole Hendrickson[1,3] (Environment Canada), Derek Hermanutz[2] (Environment Canada), Christian Houle[2] (Fisheries and Oceans Canada), Laura Kemp, Sheldon Lambert (Parks Canada), Andre Loranger,[2,3] Cecilia Lougheed (Fisheries and Oceans Canada), Bob MacGregor[1,2] (Agriculture and Agri-Food Canada), Sherri MacLeod[1,3] (Environment Canada), John Marshall, Aurelie Mogan (Agriculture and Agri-Food Canada), Dan Mulrooney[1,2] (Parks Canada), Dennis O'Farrell[1] (Environment Canada), Jean Poitevin (Parks Canada), Susan Preston[1] (Environment Canada), Troy Riche[2] (Agriculture and Agri-Food Canada), Kami Ramcharan[2,3] (Natural Resources Canada), Art Ridgeway,[2,3] Valerie Sexton[1] (Environment Canada), Mohammad Shakeri[1] (Agriculture and Agri-Food Canada), Joe St. Lawrence, Jim Tebrake,[2] Greg Strain[2] (Agriculture and Agri-Food Canada), Stéphanie Uhde (Institut de la Statistique du Québec), Judy Watling[2,3] (Policy Horizons Canada), Tony Young[2,3] (Environment Canada)

The support and co-operation of the following federal departments is also gratefully acknowledged:

Agriculture and Agri-Food Canada
Environment Canada
Fisheries and Oceans Canada
Natural Resources Canada
Parks Canada
Policy Horizons Canada

The MEGS project was a collaborative effort between Statistics Canada and the above departments. The objectives of the project were to research, consolidate data and build knowledge on ecosystems and ecosystem goods and services in Canada; to study alternatives for assessing and tracking ecosystem quality; and to assemble the information required to support the process of valuation. These objectives were accomplished by investigating spatial standards and classifications, standardizing existing spatial data, developing pilot ecosystem accounts, and investigating methods for valuation of ecosystem goods and services.

This issue of *Human Activity and the Environment* contains a compilation of selected results from these activities. As such, it is a compendium of interdisciplinary research initiatives focused on improving our understanding of the value of ecosystem goods and services through ecosystem accounting. We proudly publish these results in recognition of the International Year of Statistics.

This work would not have been possible without the generous financial contribution from the Policy Research Data Group of Policy Horizons Canada.

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3. Former committee member

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Highlights

Human Activity and the Environment 2013: Measuring ecosystem goods and services in Canada presents information on the quantity, quality and *value* of Canada's *ecosystems* and *ecosystem goods and services* (EGS). The report presents preliminary results achieved through a two-year interdepartmental project to develop experimental *ecosystem accounts* and the required statistical infrastructure. It provides an overview of ecosystem accounting and *valuation*, several measures of the quantity and quality of ecosystems and their goods and services, a case study for valuing EGS, and a research agenda for future work in this area.

Executive summary

Ecosystem goods and services (EGS) are fundamental to human activity. These tangible goods (e.g., fish, timber) and less tangible services (e.g., clean air, productive soil) are crucial to our lives and livelihoods, yet human activities can have impacts on the ecosystem structures and functions that produce them. Tracking the quantity, quality and value of EGS has never been more important.

In 2011, Statistics Canada received federal funding to develop experimental ecosystem accounts with the specific objective of supporting policy needs related to the valuation of EGS. The ensuing project, Measuring Ecosystems Goods and Services (MEGS), involved a unique partnership between Statistics Canada and Environment Canada—the project co-leads—as well as Agriculture and Agri-Food Canada, Fisheries and Oceans Canada, Natural Resources Canada, Parks Canada and Policy Horizons Canada. This report summarizes the findings of the project while investigating the quantity, quality and value of ecosystems and EGS in Canada.

Many of the findings presented in this report, particularly *land cover* and land cover change analyses, relied on the development of the MEGS geodatabase. This database, which reconciles numerous existing publicly-available spatial datasets, is a key component of the MEGS statistical infrastructure and will support accelerated research in this field. Associated with this work is the development of new ecosystem accounting concepts compatible with international initiatives such as the System of Environmental-Economic Accounts (SEEA): Experimental Ecosystem Accounting, The Economics of Ecosystems and Biodiversity (TEEB) and Wealth Accounting and the Valuation of Ecosystem Services (WAVES).

Land cover analysis is used as a starting point to study the quantity of ecosystems and their change over time. From 2001 to 2011, evergreen, deciduous and mixedwood forest areas across the country decreased from 3.1 million km^2 to 3.0 million km^2 (-4%), while shrubland increased from 2.4 million km^2 to 2.5 million km^2 (+4%). Built-up areas in and around cities and towns in southern Canada increased as a result of the transformation of cropland and forests. For example, from 2000 to 2011, 3,361 km^2 were converted to built-up area in southern Canada.

A focus on the Greater Golden Horseshoe area—a 33,200 km^2 area located to the west of Lake Ontario including the Greater Toronto Area—measures the decline of natural landscapes while populations increased. Population in the Greater Golden Horseshoe increased by 17% from 2001 to 2011. Settled areas, meanwhile, increased by 28% from 2000 to 2011.

The quality of ecosystems is explored through several innovative indicators reporting on human modifications to the landscape. The conversion of land from natural landscapes to agricultural land area and settled areas quantifies the impact that anthropogenic disturbances have had on natural landscapes. From 2001 to 2011, large shifts from natural landscapes to agricultural land occurred in the Upper South Saskatchewan (1,468 km^2) and Thompson (973 km^2) *sub-drainage areas* (SDAs). Settled area increased considerably from 2000 to 2011 in the Lake Ontario and Niagara Peninsula SDA, which includes Toronto, mostly at the expense of agricultural land. The analysis of the distribution and size of *natural land parcels* shows how much change has occurred due to increasing population and associated geographical barriers such as roads and transmission lines.

Ecosystem quality is further explored through a case study on the distribution of water purification potential in the boreal region. Lastly, *biomass* extraction is examined as a first step towards the development of indicators to explain whether human use of ecosystem goods is sustainable.

Valuation of EGS is approached from three different angles: first, market (monetary) valuation is explored through a case study of a marine and coastal ecosystem good—fish landings. This case study also includes the first ever delineation of the marine coastal fisheries *ecumene* of Canada.

Second, non-monetary valuation—valuation that uses complementary financial, social, cultural or physical measures—is explored through a study of *wetlands* in Canada, in which the various EGS provided by freshwater wetlands are analyzed. The report explains some of the limitations of current estimates of wetland area in Canada, and provides an innovative approach looking at supply and demand to improve the assessment of EGS. The analysis of wetland services such as *streamflow* regulation demonstrates the high demand for wetland services in Canada's prairie region. For example, the Missouri, Souris and Western Lake Winnipeg SDAs in the southern Prairies had the highest water flow variability in the country. A case study of the Assiniboine-Red drainage region illustrates how the value of wetland EGS can be considered among the highest in Canada.

Third, non-market monetary valuation is explored in a case study of the Thousand Islands National Park that provides experimental estimates of the annual value of ecosystem services provided by the park. The study analyzed anthropogenic pressures, such as population and agricultural activities, as well as land cover for the Thousand Islands Ecosystem and for a 100 km buffer area around it. From 1981 to 2011, population increased by 32%, the number of farms decreased by 37% and the area of farmland decreased by 28% in the Thousand Islands Ecosystem. These trends were mirrored in the 100 km buffer area—population grew 47%, while the number of farms and the area of farmland decreased by 39% and 23% respectively. The annual value of EGS flows assessed for the park is estimated to be between $12.5 million and $14.7 million (2012 dollars). Using benefit transfer methods for the valuation of individual EGS, recreational services represent $3.9 million annually.

The report closes on a research agenda describing some of the key issues that require further investigation, including improvement of spatial datasets, EGS indicators, the characterization of EGS for marine and coastal ecosystems, monetary and non-monetary valuation of EGS flows, and the identification and classification of the stock of natural capital assets and associated flows that should be included in a complete set of national ecosystem accounts.

Key highlights

The following bullets list some of the main findings from the report:

Ecosystems and their goods and services at the national level

- From 2001 to 2011, evergreen, deciduous and mixedwood forest areas across the country decreased from 3.1 million km^2 to 3.0 million km^2 (-4%), while shrubland increased from 2.4 million km^2 to 2.5 million km^2 (+4%).
- From 2000 to 2011, 3,361 km^2 were converted to built-up area in the southern part of the country.
- From 2000 to 2011, there was a 19% increase in the settled area occupying *dependable (Class 1 to 3) agricultural land* in Canada and a 29% increase on the very best Class 1 agricultural land.

Focus area: Greater Golden Horseshoe (Map 3.2)

- From 2000 to 2011, settled area in southern Ontario's Greater Golden Horseshoe region increased by 28% from 2,972 km^2 to 3,807 km^2.

- Overall, the loss of land area converted to settled area was split almost equally between agricultural and natural land, with more natural land converted outside the *greenbelt* and more agricultural land converted inside the greenbelt.

- The number of people living in the central settled area around Toronto, Oshawa and Hamilton increased 6% from 2001 to 2011, but population increased by 57% in adjacent areas.

Human landscape modification

- Natural landscapes, for example forests, wetlands, barrenlands, grasslands and shrublands, are the dominant land cover type in most areas of the country, but certain sub-drainage areas (SDAs) in the Prairies, in southern Ontario, along the St. Lawrence River Valley in Quebec, as well as in Prince Edward Island, have a higher proportion of modified landscapes when compared to other SDAs.

- From 2001 to 2011, the largest changes in land cover occurred as agricultural land reverted to natural landscapes. In the Qu'Appelle, Assiniboine, Lower South Saskatchewan and Lower North Saskatchewan SDAs, a total of 10,475 km^2 of agricultural land reverted to natural land cover.

- From 2001 to 2011, large shifts from natural landscapes to agricultural land occurred in the Upper South Saskatchewan (1,468 km^2) and Thompson (973 km^2) sub-drainage areas (SDAs).

- From 2000 to 2011, settled area increased considerably (627 km^2) in the Lake Ontario and Niagara Peninsula SDA, which includes Toronto, mostly at the expense of agricultural land.

- SDAs in southern Ontario and the Prairies that had the largest human populations and the most agricultural activity had the smallest average natural land parcel sizes in 2011.

- The Qu'Appelle SDA in the Prairies had the farthest average distance to natural land parcels in 2011 at 1,295 m.

- SDAs with the highest population and barrier densities occurred in southern Ontario and along the St. Lawrence Valley in Quebec.

Ecosystem productivity—national biomass extraction

- In 2010, an estimated 285.8 million tonnes of biomass (agricultural crops, livestock and poultry, milk, maple products and honey, forestry and fisheries) were extracted for human use from Canada's terrestrial and aquatic ecosystems.

- British Columbia accounts for the largest proportion of biomass extraction by weight, as a result of forestry activities.

- Biomass extraction related to agricultural activities was highest in Alberta, Saskatchewan and Ontario.

- The Atlantic provinces account for the majority of biomass extraction from commercial fisheries.

Marine and coastal ecosystem goods and services

- In 2011, commercial fish landings on Canada's Atlantic and Pacific coasts totalled over 850,000 tonnes and were valued at $2.1 billion.

- In 2010, direct spending on recreational fishing trips by anglers was an estimated $2.5 billion; many of these expenditures can be attributed to EGS (e.g., fish, recreation).

- On the East coast, commercial fishing, aquaculture and seafood processing activities accounted for 14% of employment in coastal ecodistricts where such activities were found in 2006. On the West coast, the comparable figure was 4%.

Freshwater wetland ecosystem goods and services

- The high variability of water flows in the Missouri, Souris and Western Lake Winnipeg SDAs help demonstrate the demand for wetland services in Canada's prairie region, since wetlands can help regulate streamflow.

- High *turbidity* levels, such as those seen for untreated surface waters supplying drinking water plants in the Prairies and St. Lawrence drainage regions in 2011, help demonstrate the demand for wetland services since wetlands help soil particles settle out of water.

- Prairie *pothole wetlands* in the Assiniboine-Red drainage region provide valuable habitat services.

Thousand Islands National Park case study (Map 4.1)

- Close to two million people lived within 100 km of the Thousand Islands Ecosystem in 2011, a 47% increase since 1981.

- From 1981 to 2011, the number of farms and the area of farmland decreased, by 39% and 23% respectively, within 100 km of the Thousand Islands Ecosystem. These trends were mirrored in the Thousand Islands Ecosystem, where the number of farms decreased by 37% and farm area decreased by 28%.

- Land cover for the Thousand Islands Ecosystem includes forest (31%), cropland and field (24%), water (22%), shrubland (11%), wetlands (7%) and built-up (6%).

- Land cover for the Thousand Islands National Park includes forest (82%), wetland (10%), shrubland (3%), built-up (2%), cropland and field (2%) and water (0.4%).

- The annual value of EGS flows assessed for the park is estimated to be between $12.5 million and $14.7 million (2012 dollars). The annual value of recreational services is estimated at $3.9 million (2012 dollars) using benefit transfer methods.

Related products

Selected publications from Statistics Canada

16-001-M	Environment Accounts and Statistics Analytical and Technical Paper Series
16-002-X	EnviroStats
16-201-S	Human Activity and the Environment: Detailed Statistics
16-257-X	Environment Accounts and Statistics Product Catalogue
16-401-X	Industrial Water Use
16-403-X	Survey of Drinking Water Plants
16-505-G	Concepts, Sources and Methods of the Canadian System of Environmental and Resource Accounts
16F0006X	Environmental Protection Expenditures in the Business Sector

Selected technical and analytical products from Statistics Canada

16-002-X200800210623	Canadian industry’s expenditures to reduce greenhouse gas emissions
16-002-X200800410751	A geographical profile of livestock manure production in Canada, 2006
16-002-X200800410752	Households’ use of water and wastewater services
16-002-X200900110821	Production of nitrogen and phosphorus from livestock manure, 2006
16-002-X200900210890	Targeting environmental protection expenditures in the manufacturing sector
16-002-X201100411600	Consumption-related greenhouse gas emissions in Canada, the United States and China

Selected CANSIM tables from Statistics Canada

153-0011	Value of timber stocks (methods I and II), annual
153-0032	Energy use, by sector, annual
153-0034	Greenhouse gas emissions (carbon dioxide equivalents), by sector, annual
153-0041	Disposal of waste, by source, Canada, provinces and territories, biennial
153-0042	Materials diverted, by source, Canada, provinces and territories, biennial
153-0043	Materials diverted, by type, Canada, provinces and territories, biennial
153-0046	Direct and indirect household energy use and household greenhouse gas emissions, annual
153-0051	Water intake in manufacturing industries, by source and by provinces, territories and drainage regions, biennial
153-0052	Capital and operating expenditures on environmental protection, by North American Industry Classification System (NAICS) and type of activity, Canada, biennial
153-0053	Capital and operating expenditures on environmental protection, by type of activity, Canada, provinces and territories, biennial
153-0062	Households and the environment survey, dwelling's main source of water, Canada and provinces, biennial
153-0064	Households and the environment survey, use of fertilizer and pesticides, Canada and provinces, biennial
153-0065	Households and the environment survey, awareness of air quality advisories and their influence on behaviours, Canada and provinces, biennial
153-0070	Water discharge in manufacturing industries, by point of discharge and North American Industry Classification System (NAICS), biennial
153-0101	Water use in Canada, by sector, biennial
378-0005	Natural resource assets and produced assets, annual

Selected surveys from Statistics Canada

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1736	Waste Management Industry Survey: Government Sector
1903	Survey of Environmental Protection Expenditures
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5115	Canadian System of Environmental and Resource Accounts - Material and Energy Flow Accounts
5120	Industrial Water Survey

Selected summary tables from Statistics Canada

- *Revenues from sales of environmental goods and services, by industry*
- *Revenues from sales of environmental goods and services, by province or territory*
- *Government pollution abatement and control expenditures*
- *Waste disposal by source, province and territory*
- *Disposal and diversion of waste, by province and territory*
- *Expenditures on environmental protection by industry and activity*
- *Capital expenditures on pollution abatement and control (end-of-pipe) by medium and industry*
- *Capital expenditures on pollution prevention by medium and industry*
- *Mineral reserves, closing stocks*
- *Energy use, by sector*
- *Greenhouse gas emissions, by sector*
- *Water use parameters in manufacturing industries, by industry group, Canada*

Section 1

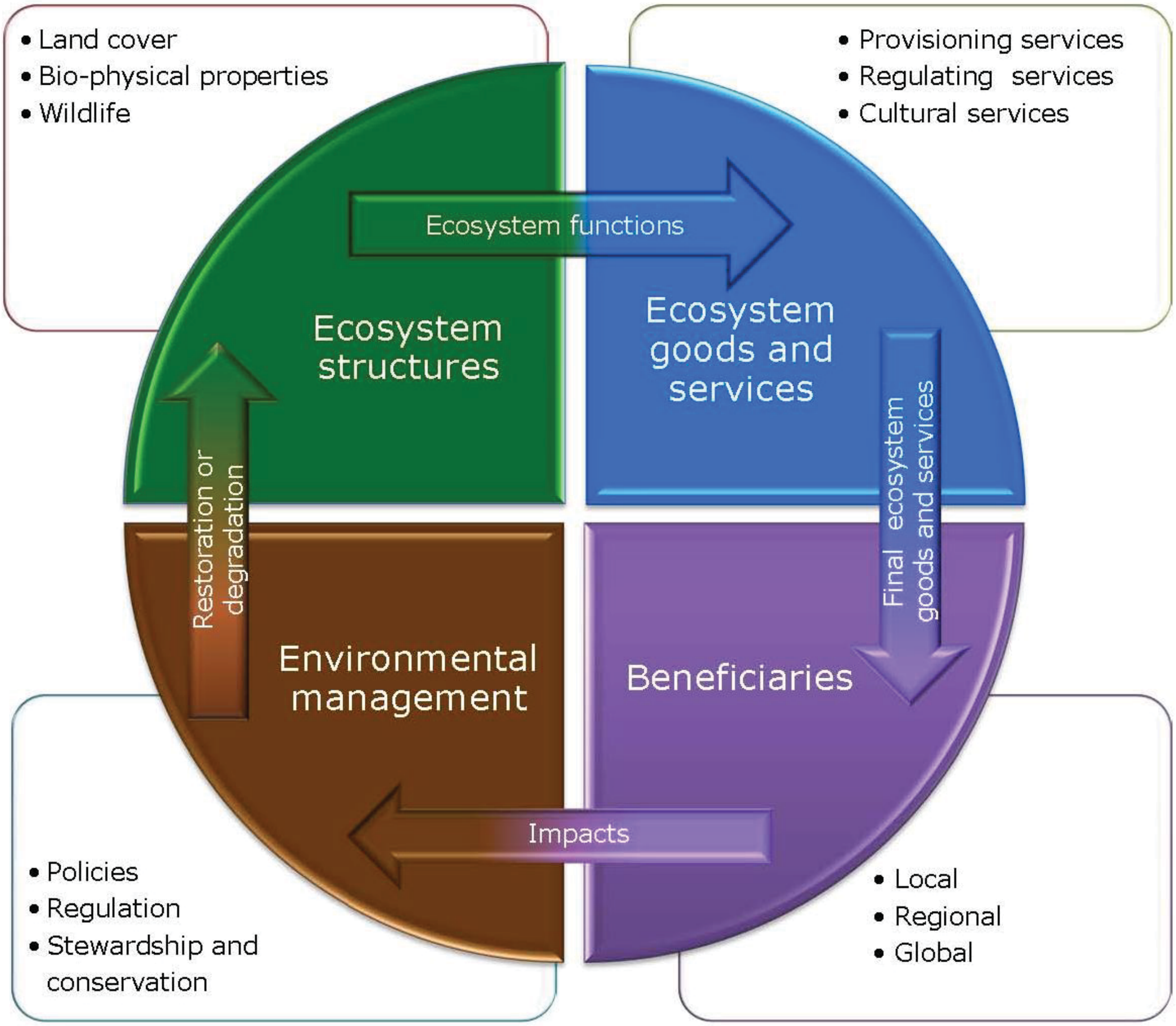
Introduction

Ecosystem goods and services (EGS) are fundamental to human activity. Farmers, foresters, fishers and many others harvest nature's bounty, while others make a living transforming and selling these goods. Ecosystem services provide social and health benefits such as education or recreation opportunities—for example, the enjoyment that we get from taking a walk in the woods or parks. Natural ecosystem structures and functions produce goods and services that benefit people—*ecosystems* produce the air we breathe, filter the water we drink, and recycle the nutrients that allow all things to grow.

Impacts from human activity on land and in the water can influence ecosystems profoundly. Climate change, ocean acidification, permafrost melting, habitat loss, *eutrophication*, stormwater runoff, air pollution, contaminants, and invasive species are among many problems facing ecosystems. The cumulative effects of these problems, as well as numerous other pressures, can have serious impacts on *ecosystem functions* and the provision of EGS. Understanding the contributions that these services make to the well-being of those who benefit from them—the beneficiaries—is important for informed decision-making. Similarly, information on the availability or degradation of EGS is needed to properly assess and design policy responses to address ecosystem conservation, restoration and sustainable use (Figure 1.1).

Figure 1.1

Measuring Ecosystem Goods and Services conceptual framework



Note(s): This diagram illustrates the MEGS conceptual framework: Ecosystem structures and processes (e.g., climate, land cover, wildlife) generate ecosystem functions which bring into being a large array of ecosystem goods and services (EGS). In MEGS, EGS are categorized in three groups: provisioning services (e.g., food), regulating services (e.g., water purification) and cultural services (e.g., whale watching). Many of these EGS are said to be "final" (as opposed to "supporting" or "intermediary") in that they benefit people directly at the local scale (e.g., farmers benefiting from productive soil), regional scale (e.g., city dwellers breathing clean air) or global scale (e.g., carbon dioxide absorbed by the oceans). As beneficiaries use or consume these EGS, their activities can result in impacts to ecosystem integrity; environmental policies, regulations and other management choices can result in the conservation, restoration or degradation of the ecosystem structures and processes that led to the supply of EGS in the first place.

Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013.

Human Activity and the Environment 2013: Measuring ecosystem goods and services in Canada reports on the results achieved during a two year project to find and develop information on ecosystem goods and services. The report is organized as follows: **Section 2: Ecosystem accounting** reviews concepts relevant to the development of experimental ecosystem accounts and case studies presented in the report. **Section 3: Ecosystems and their goods and services at the national level** presents initial broad scale results. **Section 4: Thousand Islands National Park case study** brings together some of the concepts presented in previous sections, showing how ecosystem accounting can be used in local area case studies. **Section 5: Moving forward—a research agenda** highlights selected topics that could be developed further to provide a better account of the status and trends of ecosystems and their goods and services over time. **Section 6: Appendices** provides more detailed information on some of the above topics.

This report presents preliminary results from an interdepartmental project on Measuring Ecosystem Goods and Services (MEGS). The objective of MEGS was to scope out the requirements for producing and analyzing comprehensive statistics on ecosystems and their goods and services. The focus was to build the infrastructure, develop, test and apply classifications,

Textbox 1: Measuring Ecosystem Goods and Services (MEGS)—the project:

In 2011, Statistics Canada received federal funding to develop experimental ecosystem accounts with the specific objective of supporting policy needs related to the valuation of ecosystem goods and services.

The MEGS project was a collaborative effort between several partner federal departments: Statistics Canada and Environment Canada—the project co-leads—as well as Agriculture and Agri-Food Canada, Fisheries and Oceans Canada, Natural Resources Canada, Parks Canada and Policy Horizons Canada. The objectives were to research, consolidate data and build knowledge on ecosystems in Canada; to study alternatives for assessing and tracking ecosystem quality; and to assemble the information required to support the process of valuation. These objectives were accomplished by creating spatial standards and classifications, standardizing existing spatial data, developing pilot ecosystem accounts, and investigating methods for valuation of ecosystem goods and services.

The MEGS project developed a statistical infrastructure to support the study of ecosystems, consolidated some existing data and established methods that will pave the way for future work in this area. A major output is the MEGS geodatabase, which integrates various datasets to represent land cover and land use in Canada. Initial priority was given to spatial time series data that were available nationally, although some emphasis was placed on acquiring and integrating lower level datasets where they were more appropriate. Coarse national datasets may not be appropriate in regional and local scale analysis, such as the case study on the Thousand Islands National Park presented in this report, which used higher resolution data for its land cover analysis. Progress has also been achieved in developing quality measures and advancing knowledge on monetary and non-monetary valuation.

The project team is monitoring the development of the System of Environmental-Economic Accounting (SEEA): Experimental Ecosystem Accounting, which will become a guidance manual for ecosystem accounts once finalized and adopted.[1] Results presented in this report are part of an experimental accounting exercise that is compatible with SEEA's objectives and guidelines.

quality measures and valuation methods to further the development of ecosystem accounts (Textbox 1).

Accounting for EGS is a relatively new, but growing, field of inquiry. Major challenges related to defining goods and services, understanding and tracking the biophysical properties and structures that produce the good and services, measuring where goods and services are generated and used, and valuing the services, are recognized by environmental accountants, ecologists and economists alike. However, a high degree of interjurisdictional and interdisciplinary collaboration exists to develop common standards, definitions, tools, methods and classifications, including ongoing work within the framework of the United Nations System of Environmental-Economic Accounting (UN SEEA).[2]

1. United Nations Statistics Division, 2013, *The System of Environmental-Economic Accounting (SEEA): SEEA Experimental Ecosystem Accounting*, (Draft subject to final editing), *http://unstats.un.org/unsd/statcom/doc13/BG-SEEA-Ecosystem.pdf* (accessed August 14, 2013).
2. United Nations Statistics Division, 2013.

Section 2

Ecosystem accounting

Human activity is having large and growing impacts on our natural environment.[1] Environmental degradation affects the quantity and quality of goods and services provided by ecosystems as a result of impacts on biotic and abiotic elements of ecosystems.

Ecosystems are ecological communities of living species that interact with their environment and function as a unit. For accounting purposes, the concept is generalized, with ecosystems defined as the area where living species interact among themselves and with their environment.[2] Although there is a lot of information on ecosystems and their condition, this information is not comprehensive and some data gaps remain.

The goods and services that ecosystems generate are not well understood and measured, in part because many are taken as gifts from nature. Since they are provided in abundance at no charge by the environment, most ecosystem goods and services (EGS) are not traded in markets and therefore have no explicit market value. For example, while there are markets for timber, wheat and other harvested commodities, there is no market for the air we breathe—it is not traded, has no market value and by implication may be taken for granted.

Building '*ecosystem accounts*' through the rigorous compilation of ecosystem information within a standardized framework, allows for the measurement of EGS over time and across the country, and is one way to better understand the *value* of ecosystems and their goods and services.

2.1 What is ecosystem accounting?

Ecosystem accounts compile and organize information on *ecosystem stocks*, including, for example, forests and *wetlands*. These stocks, also called *natural capital assets*, generate flows of EGS, which are the second element of ecosystem accounts. Put simply, ecosystem accounts present information about the quantity of ecosystem assets and EGS from which society benefits.

There are certain parallels between ecosystem accounting and business accounting. A country, for example, begins the year with an initial stock of forest area. Over the year, forest area may increase or decrease depending on the balance between additions due to new growth and replanting and removals due to harvesting or natural disturbances such as pests and forest fires. Throughout the year, the forest provides a flow of goods and services that include timber, oxygen, freshwater, wildlife habitat, recreational space and *carbon sequestration*. An ecosystem account would include measures of these stocks and flows using both physical and monetary terms where possible. It would also include a quality measure to help track changes in the state of the ecosystem.

The development of ecosystem accounts requires that both the stock of ecosystems and the flows of EGS be systematically grouped using consistent concepts and classifications. However, applying these standards is particularly challenging because EGS are the outcomes of complex interdependent processes within and across ecosystems.

2.1.1 Classifying stocks

It is possible to measure the extent, condition or quality of ecosystem assets. In order to do so, stocks of terrestrial ecosystems are classified based on land cover features, divided broadly into forest, grassland and tundra landscapes, while aquatic ecosystems are divided into freshwater and marine. These high level groupings are then subdivided according to local biophysical characteristics, such as soil type, elevation and ruggedness.

Given the advancement of spatial datasets and satellite image technologies, it is now possible to use more detailed land cover and land use information

1. Millennium Ecosystem Assessment, 2005, *Ecosystems and Human Well-being: A Framework for Assessment*, Washington DC, Island Press.
2. Refer to Figure 1 and Map 1 in Appendix A for further information regarding the use of land cover units as a statistical proxy representation of terrestrial ecosystems.

to better delineate stocks of ecosystems and track them over time. However, the resolution of the data source will have implications for the type and scale of analysis that can be performed. The spatial hierarchy and land cover ecosystem units developed as part of the MEGS project are described in detail in Appendix A– Measuring Ecosystem Goods and Services geodatabase.

2.1.2 Classifying flows

The classification of EGS flows has a relatively recent history[3]—efforts in this area include the Millennium Ecosystem Assessment,[4] the Economics of Ecosystems and Biodiversity study[5] and the still evolving Common International Classification for Ecosystem Services (CICES).[6]

CICES, for example, defines EGS categories and excludes intermediate goods and services[7] to avoid overlap and double counting. For this reason, CICES only includes final ecosystem outputs that benefit people. However, many intermediate ecosystem services deserve to be measured and valued. For example, food crops may be considered a final ecosystem good but their growth depends on pollination, water regulation and soil formation. In turn, pollination is dependent on bees having appropriate habitats near farmland where the crops are grown. This complex web of interactions is not clearly shown in a two-dimensional classification of ecosystem services.

For the MEGS project, EGS flows are classified into three broad categories:[8]

- *Provisioning services*—the 'goods' in EGS—reflect the material and energy provided by ecosystems; for example, timber, fish, or plants that have a particular socio-economic use.
- *Regulating services* result from the capacity of ecosystems to regulate climatic, hydrological and bio-chemical cycles, as well as biological processes.
- *Cultural services* are generated from the physical setting and location of ecosystems and give rise to emotional, intellectual and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection.

2.2 Ecosystem quality and capacity

Measuring ecosystem quality over time provides information about the state of the environment and is necessary to understand the capacity of ecosystems to provide EGS flows into the future.

Different approaches are used to estimate ecosystem quality since it can be difficult to obtain direct measures of quality and there is no universal best approach. An approach that is suitable to assess quality or health of an ecosystem in an agricultural setting, for example, may not be appropriate for the tundra or an old-growth forest.

Several indicators are available to help assess ecosystem quality. These indicators include measures of ecosystem productivity, the ecological potential of the landscape, various aspects of biodiversity including the status and trends of species, to mention but a few. The MEGS project explored the applicability of several of these indicators, making modifications based on data availability. This report includes experimental indicators covering several aspects of human disturbance of natural landscapes (Section 3.2), ecosystem services potential (Section 3.3), and biomass extraction (Section 3.4).

Other indicators of ecosystem quality focus on measuring outcomes; for example, the quality of water that has gone through natural filtering mechanisms provided by ecosystems. The EGS provided by wetlands are analyzed in this way in section 3.6.

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3. Braat, L.C. and R. de Groot, 2012, "The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy," *Ecosystem Services*, Vol. 1, Issue 1, pages 4 to 15.
4. Millennium Ecosystem Assessment, 2005, *Ecosystems and Human Well-being: General Synthesis*, Washington DC, Island Press.
5. de Groot, R., B. Fisher, M. Christie, J. Aronson, L. Braat, J. Gowdy, R. Haines-Young, E. Maltby, A. Neuville, S. Polasky, R. Portela and I. Ring, 2010, "Chapter 1: Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation," pages 9 to 40 in Kumar, P. (ed.), 2010, *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*, Earthscan, London and Washington.
6. Haines-Young, R. and M. Potschin, 2013, *Common International Classification of Ecosystem Services (CICES): Consultation on Version 4*, August-December 2012.
7. Goods and services that are used as inputs or components in the production of final goods and services.
8. United Nations Statistics Division, 2013, *The System of Environmental-Economic Accounting (SEEA): SEEA Experimental Ecosystem Accounting*, (Draft subject to final editing), *http://unstats.un.org/unsd/statcom/doc13/BG-SEEA-Ecosystem.pdf* (accessed August 14, 2013).

2.3 Valuation of ecosystem goods and services

Many goods and services are routinely traded in the economy and have well-defined prices. Markets for labour, food, or consumer goods are all well-established; people have an intuitive understanding of their relative values. By contrast, many EGS, such as water quality regulating services provided by wetlands or forests, are rarely formally bought and sold and have no specific market price. Monetary *valuation* of EGS can help address this issue by putting the benefits people receive from the environment in terms that allow comparison with other goods and services.[9]

Valuation of EGS is used in a variety of ways. In addition to raising awareness and educating the public on the importance of EGS, valuation is used to help evaluate tradeoffs involved in land development decisions, identify ecosystem conservation and restoration needs, support ecosystem accounting, develop tax policies, and evaluate compensation relating to environmental damage claims.

Numerous methods have been developed to estimate the monetary value of EGS. These methods focus on measuring the benefit or contribution that ecosystems and their functions make to human well-being. The type of policy use will determine the method[10] and the level of accuracy required.[11] However, valuation is subject to various limitations.[12] See Appendix B for more information on valuation methods and their limitations.

9. Ruitenbeek, J., Personal communication, June 30, 2012.
10. Freeman, A., 1993, "The measurement of environmental and resource values: Theory and methods," *Resources for the Future,* Washington DC.
11. Navrud, S., 2007, *Practical Tools for Value Transfer in Denmark–Guidelines and an Example,* Working Report No. 28, Danish Ministry of the Environment.
12. ten Brink, P., A. Berghöfer, A. Neuville, C. Schröter-Schlaack, A. Vakrou, S. White and H. Wittmer, 2009, "Chapter 10: Responding to the value of nature," *The Economics of Ecosystems and Biodiversity for National and International Policy Makers*.
13. Ruitenbeek, J., Personal communication, June 30, 2012.

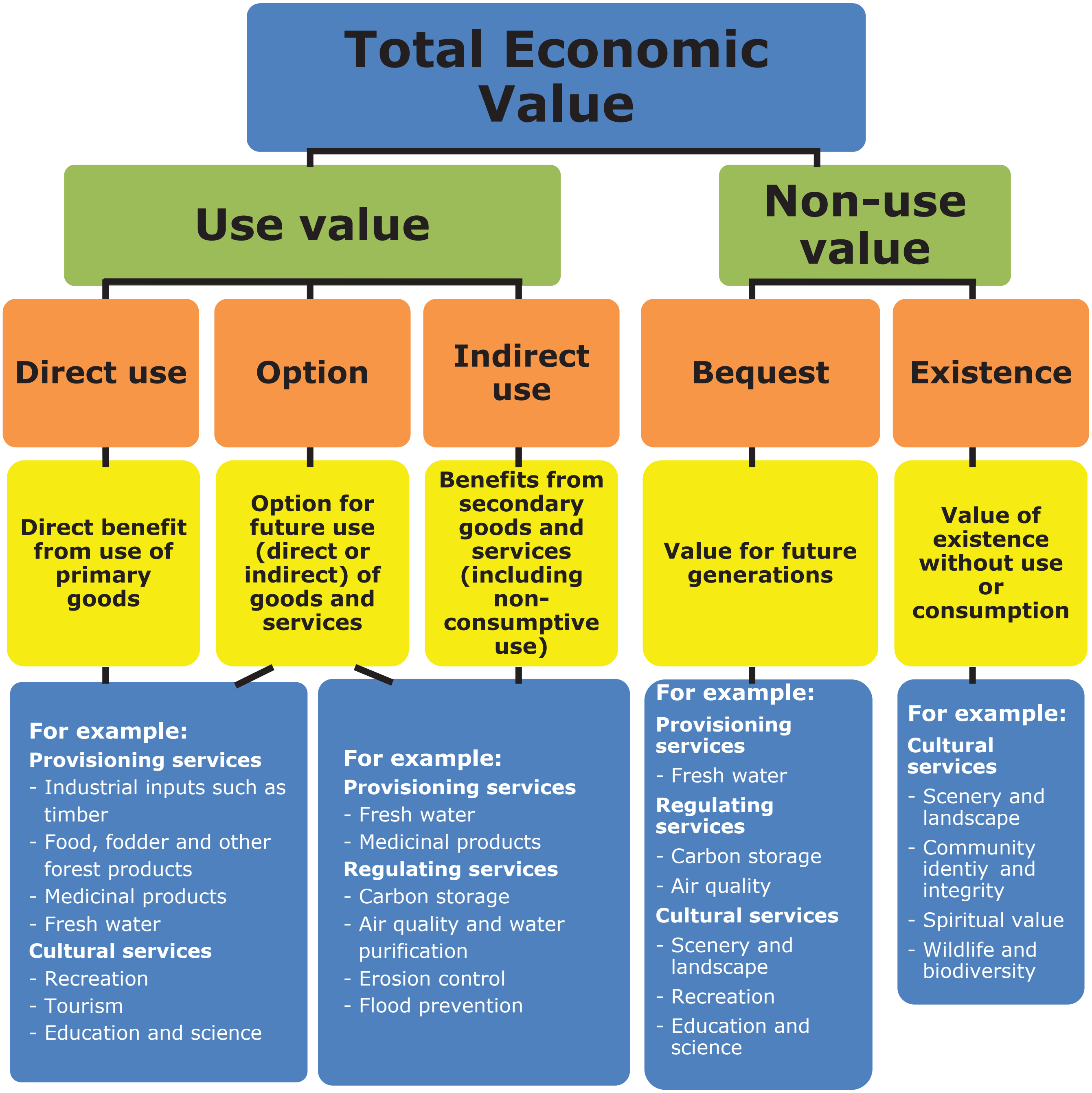
EGS valuation analyses often focus on the impact of small, incremental changes in an ecosystem or its services, rather than on overall values. This approach is useful because many policy or development decisions relate to how specific changes will impact human well-being.[13] When conducting valuation studies, it is important to consider the relationship between the location and extent of ecosystems and the proximity to human populations that will ultimately benefit from their goods and services.[14]

EGS can benefit people in different ways. The values of these different types of benefits can be grouped into ‘use’ and ‘non-use’ categories (Figure 2.1). Use values can be separated into direct use (e.g., resource extraction or recreation); indirect use (e.g., carbon sequestration and protection against natural hazards); and option value, which relates to the availability of EGS for direct and indirect use in the future. Non-use values reflect that people are made better off simply by knowing that natural environments and their elements exist (*existence value*) or that the EGS that flow from them will be available for future generations (bequest value). Non-use values, along with option value, are the least tangible of all EGS values.[15] Collectively, these different use and non-use values are referred to as ‘Total Economic Value’ (TEV) (Figure 2.1).

14. Russi, D., P. ten Brink, A. Farmer, T. Badura, D. Coates, J. Förster, R. Kumar and N. Davidson, 2013, *The Economics of Ecosystems and Biodiversity for Water and Wetlands*, Institute for European Environmental Policy, London and Brussels, Ramsar Secretariat, Gland.
15. White, S., B. Simmons, P. ten Brink and V. Weick, 2009, "Chapter 4: Integrating ecosystem and biodiversity values in policy assessment," *The Economics of Ecosystems and Biodiversity for National and International Policy Makers*.

Figure 2.1

'Total Economic Value' framework



Adapted from: The Economics of Ecosystems and Biodiversity, 2009, *The Economics of Ecosystems and Biodiversity for National and International Policy Makers*.

TEV is most useful as a conceptual tool that allows decision-makers to consider a potentially wide range of costs or values when assessing a given policy option. Despite the name however, not all of the values suggested by the TEV framework can or should be added together.[16] This is in part because many uses are mutually exclusive—a tract of forest used for its timber cannot at the same time provide erosion control services. As well, data required to estimate values for all services are rarely available for a given valuation exercise.

In addition to monetary valuation of EGS, other complementary financial, social, cultural or physical measures can also be used to assess the value of ecosystems and their benefits. These may include non-monetary values such as lives saved, nutrients processed by wetlands and others. Depending on the type of analysis being undertaken, both monetary and non-monetary values can be relevant.

Canadian valuation efforts include work to develop the Environmental Valuation Reference Inventory (EVRI) database, a reference and decision-making resource managed by Environment Canada that is used by researchers around the world.[17] Other efforts include incorporating valuation into environmental assessment processes. For example, assessing tradeoffs related to water use in Alberta[18] and coastal planning using an ecosystem-based management approach in British Columbia.[19]

Canadian think tanks and environmental non-governmental organizations also use valuation to raise awareness about values associated with EGS across large geographic areas and in respect to specific environmental issues, such as land use change. For example, the David Suzuki Foundation recently published a report that estimates the economic value of various EGS in the greenbelt of the Greater Montréal region.[20]

16. Ruitenbeek, J., Personal communication, June 30, 2012.
17. Environment Canada, 2011, *Environmental Valuation Reference Inventory (EVRI)*, *www.evri.ca* (accessed July 11, 2013).
18. Ruitenbeek, J., Personal communication, June 30, 2012.
19. British Columbia Ministry of Forests, Lands and Natural Resource Operations, n.d. (no date), *Ecosystem Based Management – BC's Central and North Coast*, *www.ilmb.gov.bc.ca/category/subject-area/land-management/EBM* (accessed June 5, 2013).
20. David Suzuki Foundation and Nature-Action Québec, 2013, *Le capital écologique du Grand Montréal : Une évaluation économique de la biodiversité et des écosystèmes de la Ceinture verte*, *www.davidsuzuki.org/fr/publications/telechargements/2012/Rapport%20Ceinture%20Verte_BSE_FDS_web_Fev2013.pdf* (accessed July 16, 2013).

Section 3

Ecosystems and their goods and services at the national level

Canada's main ecosystem types include forests, wetlands, grasslands, tundra, lakes, rivers, and coastal and marine areas. At this large scale, changes in the quality of terrestrial and aquatic ecosystems can be seen by measuring changes in variables such as land cover or ecosystem productivity over time.

This section presents an overview of measures of the quality and productivity of ecosystems using a suite of national level experimental indicators developed as part of the MEGS project. These indicators were designed and developed to measure land cover change, landscape modification, ecosystem service potential and biomass extraction. In addition, measures of fish harvest—an important provisioning service from marine areas—and measures of ecosystem goods and services (EGS) provided by wetlands are also presented.

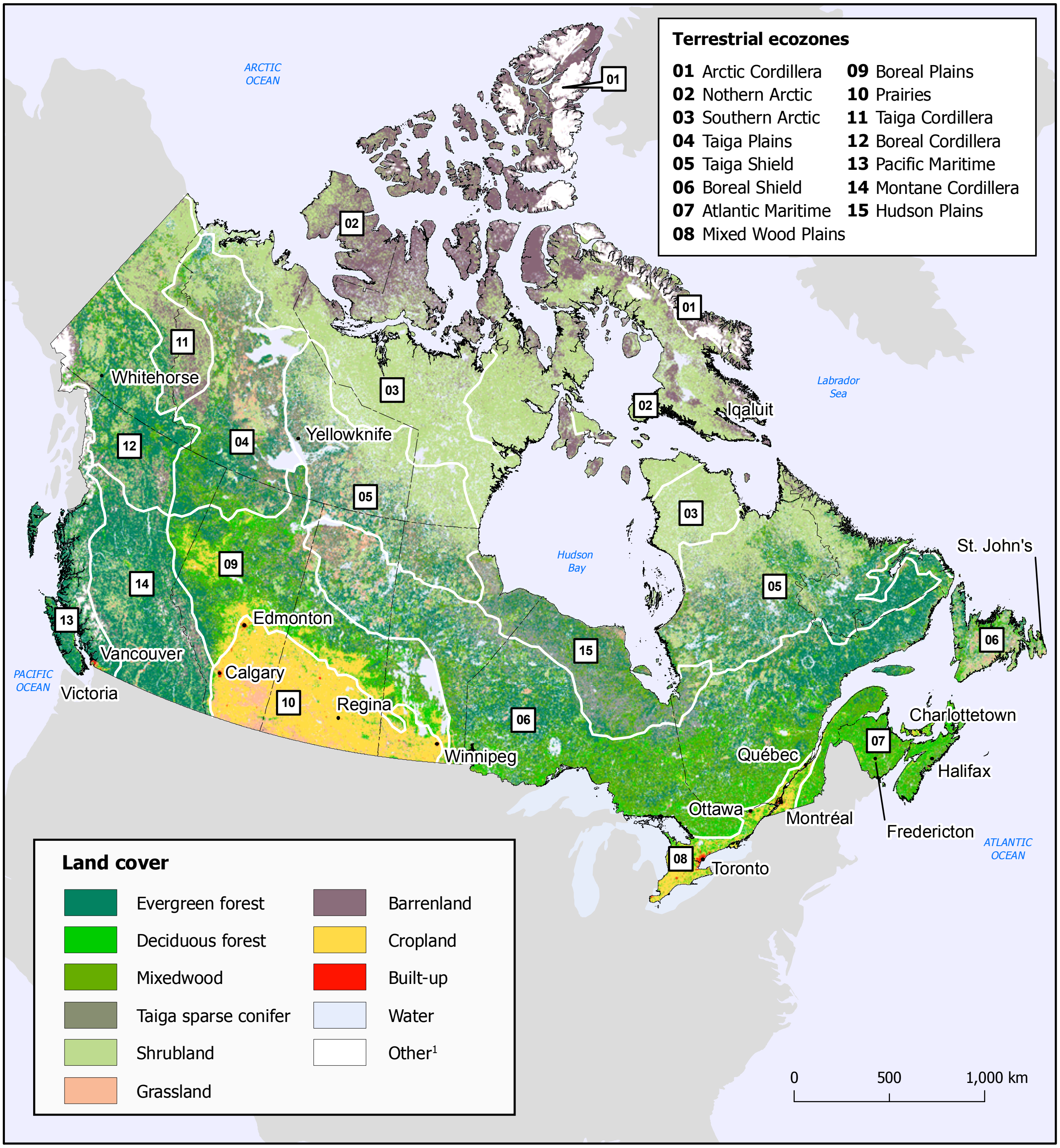
3.1 Land cover change, Canada

Tracking changes in *land cover* and *land use* is a useful starting point for studying the state of terrestrial ecosystems. Land cover change resulting from developmental pressures such as the expansion of roads and settlements can affect the quality of ecosystems and their capacity to deliver EGS. However, land cover alone cannot fully explain land's ability to support and maintain ecological processes and functions. For example, the corridors connecting natural land parcels are important determinants of land's ability to support habitat and wildlife.

Broadscale analysis of land cover based on the MEGS geodatabase shows that forest and shrubland are the dominant land covers in taiga and boreal ecozones,[1] a majority of the Prairies is in cropland and Canada's arctic is mostly barren (Map 3.1).

1. For information about the ecozone geographical unit used in this analysis see Appendix H Geographies.

Map 3.1
Land cover, by ecozone, 2011



1. Combines Canada Centre for Remote Sensing (CCRS) land cover codes for wetlands, snow and ice.

Source(s): Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing, ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/ (accessed May 8, 2013). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

From 2001 to 2011, evergreen, deciduous and mixedwood forest areas across the country decreased from 3.1 million km^2 to 3.0 million km^2 (-4%), while shrubland increased from 2.4 million km^2 to 2.5 million km^2 (+4%). Built-up areas in and around cities and towns across Canada increased 8% from 8,996 km^2 to 9,680 km^2 over the same period (Table 3.1). Put in perspective, these areas grew by an area roughly the size of the City of Toronto.

Table 3.1
Land cover, Canada, 2001 and 2011

	Evergreen forest	Deciduous forest	Mixedwood	Taiga sparse conifer	Shrubland	Grassland	Barrenland	Cropland	Built-up	Water	Other [1]	Total
	square kilometres											
Area in 2001	2,054,955	435,811	638,199	1,006,544	2,373,331	258,521	1,008,826	540,559	8,996	997,539	652,901	9,976,182
Area in 2011	1,915,932	467,710	620,594	977,445	2,456,596	332,903	1,012,016	540,684	9,680	1,000,946	641,676	9,976,182
Change from 2001 to 2011	-139,023	31,899	-17,606	-29,099	83,265	74,382	3,190	125	684	3,407	-11,225	…
Percent change from 2001 to 2011	-6.8	7.3	-2.8	-2.9	3.5	28.8	0.3	0[s]	7.6	0.3	-1.7	…

1. Combines Canada Centre for Remote Sensing (CCRS) land cover codes for wetlands, snow and ice.

Note(s): Measuring land cover categories is subject to certain limitations due to difficulties in distinguishing between different land cover types. This land cover area was derived from CCRS 250 m land cover data. Because of the coarseness of this data, areas may not be consistent with other released tabulations which used more detailed data.

Source(s): Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011,* Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Many of these changes are the result of the transformation of cropland and forests in the areas surrounding cities and towns (Table 3.2). For example, from 2000 to 2011, 3,361 km^2 were converted to built-up area in the southern part of the country.[2]

2. This land cover change data was derived from 30 m resolution land cover; results are more precise than other land cover tabulations using Canada Centre for Remote Sensing (CCRS) 250 m. Geographic coverage of this data is presented in Map 1 (Appendix C).

Table 3.2
Land cover change, southern Canada, 2000 and 2011

	To (2011)								
	Evergreen forest	Deciduous forest	Mixedwood	Shrubland	Grassland	Barrenland	Cropland	Built-up	Water [1] natural and artificial and wetlands
	square kilometres								
From (2000)									
Evergreen forest	…		297.9				521.7	211.8	
Deciduous forest	3,922.2	…	6,053.1	1,044.3			5,543.2	320.8	
Mixedwood			…				380.5	92.8	
Shrubland	3,637.4		3,102.1	…					
Grassland	454.4	147.8	17.9	750.3	…	1,552.6	6,983.7 [2]	332.0	178.2
Barrenland	1,539.1	16.2	453.4	450.9		…		72.3	
Cropland				9,117.8		911.3	…	2,252.5	2,653.7
Built-up				34.2				…	
Water natural and artificial and wetlands [1]	3,519.1	382.1	2,059.6	1,320.2	87.7	344.5		79.3	…

1. Water and wetland areas derived from satellite imagery are influenced by climatic conditions at the time the images were taken. This should be considered when interpreting the data.
2. Distinguishing grasslands from certain crops is difficult and therefore considerable caution should be used in interpreting this change.

Note(s): This table presents change in land cover area from 2000 to 2011. For example, 3,922.2 km^2 moved from deciduous forest to evergreen forest from 2000 to 2011. Blank cells indicate no positive change from one category to the other. Measuring land cover categories is subject to certain limitations due to difficulties in distinguishing between different land cover types. This land cover change data was derived from 30 m resolution land cover; results in this table are more precise than other land cover tabulations using Canada Centre for Remote Sensing (CCRS) 250 m land cover data. Geographic coverage of this data is presented in Map 1 (Appendix C).

Source(s): Agriculture and Agri-Food Canada, 2009, *Land Cover for Agricultural Regions of Canada (circa 2000),* version 12, *http://data.gc.ca/data/en/dataset/f5ded3b0-a5b4-4599-95d6-d853a825792b* (accessed October 9, 2012). Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada,ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

The loss of some of Canada's best agricultural land through conversion to other uses is a concern given the limited amount of this non-renewable resource. Only about 5% of land in Canada is free from severe constraints to crop production.[3] From 2000 to 2011, there was a 19% increase in the settled area occupying this *dependable agricultural land* in Canada and a 29% increase on the very best Class 1 agricultural land.[4,5]

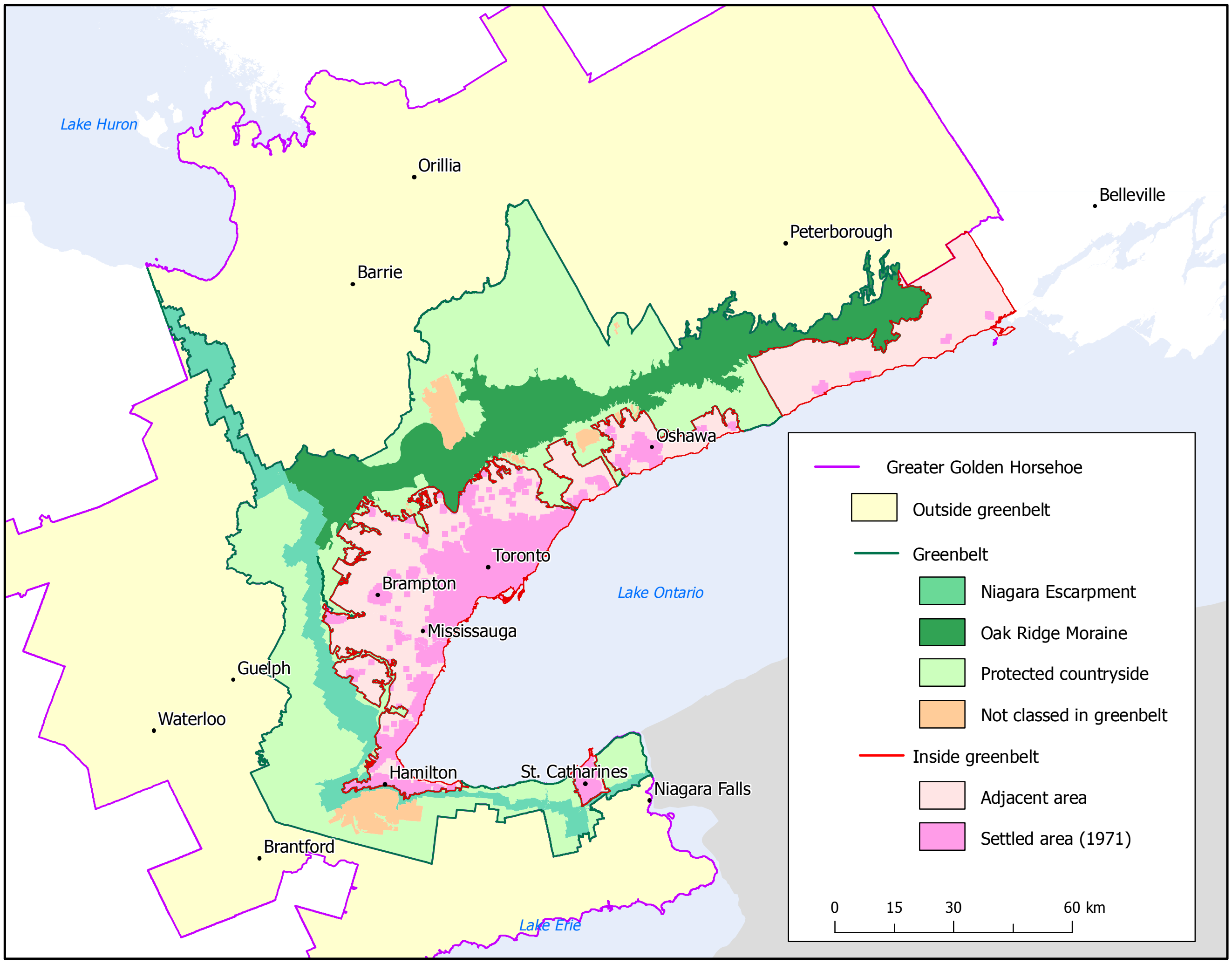
Some cropland also reverted to a more natural land cover, with 9,118 km^2 shifting to shrubland from 2000 to 2011 (Table 3.2).

3.1.1 Focus area: Greater Golden Horseshoe

Land cover analyses can also focus on changes at regional or local scales.[6] In southern Ontario, the Greater Golden Horseshoe area covers almost 33,200 km^2. Located to the west of Lake Ontario, it includes some of Canada's largest cities (Map 3.2). The area, named for its economic wealth and horseshoe shape, has a high concentration of economic activity, as well as some of Canada's best agricultural land. In 2011, the Greater Golden Horseshoe was home to 26% of the Canadian population.

3. Hofmann, N., G. Filoso and M. Schofield, 2005, "The loss of dependable agricultural land in Canada," *Rural and Small Town Canada Analysis Bulletin,* Statistics Canada Catalogue no. 21-006-X, Vol. 6, no. 1.
4. "Dependable" agricultural land is land designated as Class 1, Class 2 and Class 3 by the Canada Land Inventory (McCuaig, J.D. and E.W. Manning, 1982, *Agricultural Land Use Change in Canada: Process and Consequences*, Environment Canada, Lands Directorate, Catalogue no.73-1/21E) and includes all land areas that are not affected by severe constraints for crop production.
5. Statistics Canada, Environmental Accounts and Statistics Division, 2013, special tabulation based on Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012) and Natural Resources Canada, 1999, *Canada Land Inventory: Soil Capability for Agriculture (1: 250,000)*, *www.geogratis.gc.ca* (accessed 2001). This analysis, which uses a land cover compilation based on satellite imagery, is not compatible with analysis previously reported in Hofmann, N., G. Filoso and M. Schofield, 2005, "The loss of dependable agricultural land in Canada," *Rural and Small Town Canada Analysis Bulletin*, Statistics Canada Catalogue no. 21-006-X, Vol. 6, no. 1, due to differences in the data sources and methodologies.
6. The resolution of available satellite data sources will have an impact on the precision and accuracy of land cover analyses.

Map 3.2
Greater Golden Horseshoe



Note(s): The settled area boundary inside the greenbelt is derived from a special tabulation of data from the 1971 Census of Population. The greenbelt boundary is defined by the Government of Ontario's *Greenbelt Act, 2005*. The adjacent area identified here is the area between the 1971 settled area and the greenbelt.

Source(s): David Suzuki Foundation, 2013, *Nature on the Edge: Natural Capital and Ontario's Growing Golden Horseshoe*, www.davidsuzuki.org/publications/downloads/2012/DSF_whitebelt_2013_web_edited_version.pdf (accessed August 13, 2013). Ontario Ministry of Municipal Affairs and Housing, 2013, *The Greenbelt Act, 2005*, www.mah.gov.on.ca/Page195.aspx (accessed June 27, 2013). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1971 Census of Population.

Increasing urbanization in the Greater Golden Horseshoe has placed pressure on the landscape. Within the Greater Golden Horseshoe, population has grown from 4.5 million in 1971 to 8.7 million in 2011 (Table 3.3). In 1971, two-thirds of the population living in the Greater Golden Horseshoe was located in the central settled areas around Toronto, Oshawa and Hamilton, inside the *greenbelt*. With increasing population growth, the number of people living in these areas increased by 36%. However, population growth increased much more in the adjacent area, increasing from 39,148 in 1971 to 1.8 million in 2011. Overall, the proportion of the population living inside the greenbelt, in the greenbelt and outside the greenbelt remained largely unchanged over the same period.

Table 3.3
Population, Greater Golden Horseshoe, 1971, 2001 and 2011

	1971	Share of total population 1971	2001	Share of total population 2001	2011	Share of total population 2011	Change 1971 to 2011	Change 2001 to 2011
	persons	percent	persons	percent	persons	percent		
Total	**4,528,587**	**100.0**	**7,444,233**	**100.0**	**8,686,923**	**100.0**	**91.8**	**16.7**
Inside greenbelt	3,094,087	68.3	5,077,991	68.2	5,959,729	68.6	92.6	17.4
Settled area [1]	3,054,939	67.5	3,919,451	52.7	4,146,412	47.7	35.7	5.8
Adjacent area [2]	39,148	0.9	1,158,540	15.6	1,813,317	20.9	10,491.6	56.5
Greenbelt [3]	443,269	9.8	507,548	6.8	935,115	10.8	111.0	84.2
Niagara Escarpment	88,679	2.0	102,593	1.4	106,147	1.2	19.7	3.5
Oak Ridges Moraine	52,270	1.2	125,305	1.7	200,116	2.3	282.9	59.7
Protected countryside	163,090	3.6	279,650	3.8	312,249	3.6	91.5	11.7
Within greenbelt not classed	139,230	3.1	266,140	3.6	316,603	3.6	127.4	19.0
Outside greenbelt	991,231	21.9	1,592,554	21.4	1,792,079	20.6	80.8	12.5

1. Settled area boundary inside the greenbelt is based on the 1971 Census of Population.
2. The adjacent area identified here is the area between the 1971 settled area and the greenbelt.
3. Greenbelt area boundary is defined by the Government of Ontario's *Greenbelt Act, 2005*.

Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1971, 2001 and 2011 Censuses of Population.

Recognizing the developmental pressures associated with population growth, in 2005 the government of Ontario established a 'greenbelt' covering 22% of the Greater Golden Horseshoe area, protecting farmland, wetlands, forests and other green space from urban development.[7] When the greenbelt was established, the area between it and the existing settled areas was identified to accommodate further urban expansion and is known as the *whitebelt*. Consisting of rural and agricultural land, this area is under pressure from population growth and competing land uses.

From 2000 to 2011, settled area in the Greater Golden Horseshoe increased by 28%, from 2,972 km^2 to 3,807 km^2 (Table 3.4). For the area outside the greenbelt, the largest proportion of this change occurred as natural land[8] was converted to settled area. Inside the greenbelt, almost 300 km^2 was converted to settled area, more than two-thirds of which was converted from agricultural land area. Given the limited availability of good quality agricultural land in Canada, losses of this non-renewable resource could have implications for longer-term agricultural sustainability.

7. Ontario Ministry of Municipal Affairs and Housing, 2013, *The Greenbelt Act, 2005*, *www.mah.gov.on.ca/Page195.aspx* (accessed June 27, 2013).
8. Includes forest, wetland, barrenland, grassland or shrubland that has predominantly natural or naturalizing characteristics.

Table 3.4
Land cover, Greater Golden Horseshoe, 2000 and 2011

	Outside greenbelt				Greenbelt				Inside greenbelt			
	Settled area [1]	Agricultural land area [2]	Natural or naturalizing area [3]	Water [4]	Settled area [1]	Agricultural land area [2]	Natural or naturalizing area [3]	Water [4]	Settled area [1]	Agricultural land area [2]	Natural or naturalizing area [3]	Water [4]
	square kilometres											
2000	914	10,985	8,525	1,671	382	4,266	2,642	77	1,676	1,399	620	42
2011	1,209	10,950	8,392	1,543	622	4,172	2,515	57	1,976	1,193	535	34
Change 2000 to 2011	295	-35	-132	-128	240	-94	-126	-20	299	-206	-85	-8

1. Settled area is based on Agriculture and Agri-Food Canada's 30 m land cover code for developed areas.
2. Agricultural land area is based on the Census of Agriculture variable total farm area.
3. Natural and naturalizing area is based on the residual landscape of a sub-drainage area that is not settled or used for agriculture. It also excludes large bodies of water.
4. Water area derived from satellite imagery is influenced by climatic conditions at the time the images were taken. This should be considered when interpreting the data.

Note(s): Measuring land cover categories is subject to certain limitations due to difficulties in distinguishing between different land cover types. This land cover change data was derived from 30 m resolution land cover; results in this table are more precise than other land cover tabulations using Canada Centre for Remote Sensing (CCRS) 250 m land cover.

Source(s): Agriculture and Agri-Food Canada, 2009, *Land Cover for Agricultural Regions of Canada (circa 2000),* version 12, *http://data.gc.ca/data/en/dataset/f5ded3b0-a5b4-4599-95d6-d853a825792b* (accessed October 9, 2012). Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada,ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (October 9, 2012). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

3.2 Ecosystem quality measure: Human landscape modification

Landscapes that are least disturbed by human activity are generally better able than modified landscapes to maintain the complex ecological functions that support the production of EGS. Land cover, landscape measures and human pressures were analyzed by *sub-drainage area* (SDA)[9] in order to better understand the status of terrestrial landscapes.

This assessment focuses on five measures of ecosystem quality: landscape type, natural land parcel size,[10] distance to natural land parcel,[11] barrier density[12] and population density (Tables 1, 2 and 3, Appendix C). These measures provide information on the overall integrity of natural areas and present changes in land cover and population as indicators of the quality of terrestrial ecosystems. Together, these five *human landscape modification* measures provide information about how human activity has modified natural land areas across Canada.

9. Statistics Canada's Standard Drainage Area Classification hierarchy provides geographical units that are consistent over time allowing compilation of statistics by hydrographical areas. It includes ocean drainage areas, major drainage areas, sub-drainage areas (SDAs), as well as sub-sub-drainage areas covering the whole of Canada (Map 2, Appendix H). See Appendix H for more information on geographical units.
10. Natural land parcel size refers to the size of continuous natural and/or naturalizing land areas including forests, wetlands, barrenlands, grasslands and shrublands, measured in km^2.
11. Distance to natural land parcel is defined as the average distance from any location within an SDA to a natural land parcel.
12. Barrier density refers to the density of roads, rail lines and electrical transmission lines that fragment landscapes, but excludes other types of supporting infrastructure such as pipelines, measured in km of barriers/km^2 of land.
13. The MEGS project only addressed the terrestrial portion of landscapes for this analysis. While water was considered out of scope in this experimental work, it is acknowledged as a part of landscapes that should be evaluated in the future.
14. Naturalizing landscapes have previously been modified from their natural state, but have been left undisturbed and are transitioning to a more natural land cover (e.g., cleared land reverting to forest area). The new natural state may or may not be similar to the original natural land cover.

3.2.1 Landscape type

The type of landscape, as well as changes in land cover over time, can provide information on the degree of human modification to the landscape and changes in the provision or flow of EGS. Terrestrial landscapes[13] are grouped here into three categories: natural or naturalizing areas,[14] agricultural land areas and settled areas.[15]

Natural landscapes represent some of the least modified areas including forests, wetlands, barrenlands, grasslands and shrublands. Agricultural land can be moderately to highly modified from the natural landscape, while settled areas are highly modified from their natural state. The conversion of land to a more highly modified state can affect

15. Settled area is based on Agriculture and Agri-Food Canada's 30 m land cover code for developed areas.

ecosystem productivity. For example, the conversion of land from a natural area to a settled area can have impacts on available habitat and biodiversity. However, the term 'natural' does not imply these areas are all highly productive—some natural landscapes may not be significant providers of EGS.

Natural landscapes are the dominant land cover type in most areas of the country, but certain areas of the Prairies, southern Ontario, the St. Lawrence River Valley in Quebec, as well as Prince Edward Island, have a much higher proportion of modified landscapes when compared to other SDAs (Table 2, Appendix C).

SDAs with the lowest percentage of natural landscapes in 2011 were found in the Prairies in the Lower South Saskatchewan-05H (8.5%) and Battle-05F (8.9%). These SDAs also had the highest percentage of agricultural landscape.

SDAs with the highest percentage of settled land were located in the heavily populated areas of the Windsor to Québec City corridor in southern Ontario and Quebec. They include the Lake Ontario and Niagara Peninsula-02H, with settlements covering 11.4% of the landscape; the Central St. Lawrence-02O (7.7%) and the Northern Lake Erie-02G (6.6%).

3.2.2 Conversion to and from natural or naturalizing and agricultural landscapes

From 2001 to 2011, the largest changes in land cover occurred as agricultural land reverted to natural or naturalizing landscapes.[16] The largest shifts occurred in the southern Prairies, particularly in the Qu'Appelle-05J, Assiniboine-05M, Lower South Saskatchwan-05H and Lower North Saskatchwan-05G SDAs which together saw an area of 10,475 km^2 reverting to a natural or naturalizing landscape from agricultural land. To put this figure in context, this change represents an area three times greater than the land area of the Regina census metropolitan area (CMA). Other large shifts occurred in the Upper Peace-07F SDA, where 1,258 km^2 reverted to a natural or naturalizing state.

The largest conversions to agricultural land were from natural landscapes and these occurred in the Upper South Saskatchewan-05A (1,468 km^2) and the Thompson-08L (973 km^2) SDAs.

3.2.3 Conversion to settled landscapes

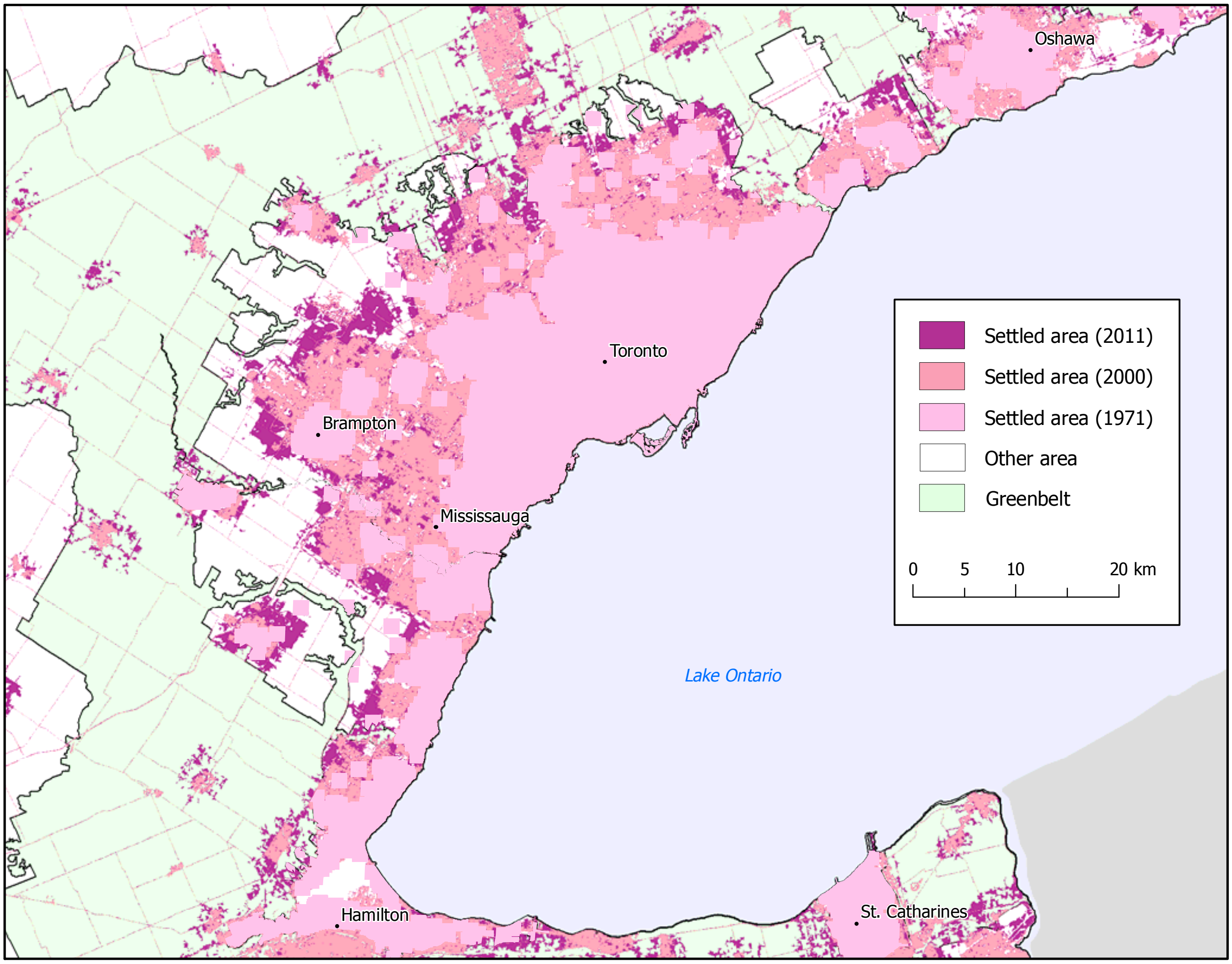
Between 2000 and 2011, 3,158 km^2 was converted from agricultural and natural land to settled areas. The largest increases in settled landscapes from 2000 to 2011 occurred in Ontario and Quebec. The largest single increase of any SDA was in the Lake Ontario and Niagara Peninsula-02H SDA, which includes Toronto—an increase of approximately 627 km^2 in settled area—mostly at the expense of agriculture (Map 3.3).

Other large increases in settled area occurred in the Central St. Lawrence-02O (311 km^2), Northern Lake Erie-02G (310 km^2), Bow-05B (201 km^2) and Central North Saskatchewan-05E (198 km^2). Most of these increases were also at the expense of agricultural land.

There were no substantial decreases in settled landscapes anywhere in Canada.

16. This trend is consistent with an overall decline in total farm area from 2001 to 2011. For more information, see Statistics Canada, 2012, *Farm and Farm Operator Data*, Catalogue no. 95-640-X.

Map 3.3
Area converted to settled landscapes within the Lake Ontario and Niagara Peninsula-02H sub-drainage area, 1971, 2000 and 2011



Note(s): The greenbelt boundary is defined by the Government of Ontario's *Greenbelt Act, 2005*.

Source(s): David Suzuki Foundation, 2013, *Nature on the Edge: Natural Capital and Ontario's Growing Golden Horseshoe*, www.davidsuzuki.org/publications/downloads/2012/DSF_whitebelt_2013_web_edited_version.pdf (accessed August 13, 2013). Ontario Ministry of Municipal Affairs and Housing, 2013, *The Greenbelt Act, 2005*, www.mah.gov.on.ca/Page195.aspx (accessed June 27, 2013). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1971 Census of Population. Agriculture and Agri-Food Canada, 2009, *Land Cover for Agricultural Regions of Canada (circa 2000)*, version12, http://data.gc.ca/data/en/dataset/f5ded3b0-a5b4-4599-95d6-d853a825792b (accessed October 9, 2012). Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/ (accessed October 9, 2012).

3.2.4 Natural land parcel sizes

The size of natural land parcels can provide insight about landscape fragmentation and also its ability to maintain ecosystem functions. For example, larger natural areas generally provide better habitat for wildlife.[17] Smaller areas may provide fewer resources and may result in increased competition between species, which can lead to effects like decreased species richness.

The smallest average natural land parcel sizes in the country are found in SDAs with the largest human populations and the most agricultural activity, including the Prairies and southern Ontario. The two southern Ontario SDAs of Eastern Lake Huron-02F and Northern Lake Erie-02G had average natural land parcel sizes of 0.8 km^2 and 0.3 km^2 in 2011. The average parcel size for eight (O5E to 05J and O5M to 05O) of the most modified SDAs in the Prairies was between 0.3 km^2 and 0.8 km^2, among the smallest in Canada.

Natural land parcel sizes are generally larger in the Maritimes than in the highly modified landscapes of the Prairies, southern Ontario and the St. Lawrence Valley in Quebec. Prince Edward Island-01C had the smallest average natural land parcel size in the Maritimes (2.3 km^2).

In comparison, the average natural land parcel size in the Lower Fraser-08M SDA in B.C. was 80.6 km^2.

3.2.5 Distance to natural land parcels

The average distance to a parcel of natural land provides another indication of the level of landscape modification. For example, the distance to natural land parcels can affect the ability of pollinators to disperse pollen from one natural area to another. As the distance increases, it becomes more difficult for species to move from one area to another, potentially decreasing genetic diversity.

The farthest average distance to natural land parcels is found in the Prairies in the Qu'Appelle-05J SDA, with an average distance of 1,295 m in 2011. The Souris-05N and Lower South Saskatchewan-05H SDAs also have an average distance to natural land parcels of greater than one kilometre (Table 3, Appendix C).

In the other highly modified landscapes of southern Ontario and the St. Lawrence Valley in Quebec, there are three SDAs (O2F, O2G and O2M) with average distances to natural landscapes of over 250 m. Prince Edward Island-01C has the farthest average distance in the Maritimes with an average distance of about 230 m. In contrast, many SDAs had short average distances to natural land parcels, for example, the Abitibi-04M SDA in Quebec had an average distance of 9 m.

3.2.6 Barrier and population densities

Roads and infrastructure such as rail and transmission lines represent another type of landscape fragmentation. These linear features cut across the landscape, splitting it into smaller patches. These barriers generally degrade habitat, though they increase the perimeter of natural areas, which can be beneficial for some species. Roads also increase access to natural landscapes, allowing better provision of recreational and educational services.[18]

Barrier density, population, and settled areas are interconnected issues. Higher barrier densities generally coincide with higher population densities, as seen in all four SDAs in southern Ontario (02E to 02H), the Upper and Central St. Lawrence SDAs in Quebec (02M and 02O), Red-05O SDA in the Prairies and Prince Edward Island-01C (Tables 1 and 3, Appendix C).

SDAs with the highest population densities from 2001 to 2011 are in southern Ontario and along the St. Lawrence Valley in Quebec. The highest densities are in Lake Ontario and Niagara Peninsula-02H SDA (272 people/km^2) and Central St. Lawrence-02O (148 people/km^2). Barrier densities are also high in these two SDAs, which include the cities of Toronto and Montréal, with an average of 2.2 km and 1.8 km of barriers/km^2 respectively.

In the Maritime Provinces, Prince Edward Island-01C has the highest population density at 25 people/km^2 and the highest barrier density of 1.4 km/km^2. In the Prairies, the Bow-05B has the highest population density at 52 people/km^2, while on the West coast, the Lower Fraser-08M, has a density of 33 people/km^2.

17. Federal, Provincial and Territorial Governments, 2010, *Canadian Biodiversity: Ecosystem Status and Trends 2010*, Canadian Councils of Resource Ministers, *www.biodivcanada.ca/ecosystems* (accessed May 29, 2013).

18. European Environment Agency, 2011, *Landscape Fragmentation in Europe*, Joint European Environment Agency (EEA) and Swiss Federal Office for the Environment (FOEN) report, EEA report no. 2/2011, EEA, Copenhagen.

Some of the largest increases in population densities are in the Prairies and southern Ontario—population density increased in the Upper North Saskatchewan-05D (27%), Bow-05B (28%), Red Deer-05C (19%), Central North Saskatchewan-05E (19%) and Lake Ontario and Niagara Peninsula-02H (16%).

These five indicators—landscape type, natural land parcel size, distance to natural land parcel, barrier density and population density—can be related and when viewed together they can help create a useful representation of the overall quality of an ecosystem.

3.3 Ecosystem services potential: Boreal forest case study

Ecosystem service potential is the capacity of landscapes to deliver goods and services without affecting ecosystem integrity.[19,20] This capacity is controlled by the ecosystem's biophysical structures and processes such as climate, soils, land cover and productivity, which interact to generate ecosystem functions.[21] While ecosystem services require a human beneficiary to be considered as such, the potential to provide that service exists independently of use.

A framework for quantifying the potential of landscapes to provide EGS was developed in the context of the MEGS project. The boreal[22] forest case study was used to test and demonstrate the value of this approach (Appendix D). Ecosystem services that were addressed in the case study were habitat provision, carbon sequestration, resilience to epidemic insect outbreaks, opportunities for solitary wilderness experiences, prey for hunting, timber supply, scenic beauty, habitat for charismatic or iconic species, air filtration, soil fertility, and water purification.

The case study also applied an aggregate measure for assessing the total *ecosystem potential*—the overall relative ecosystem capability to deliver a number of different ecosystem services—while also representing the individual contribution of each EGS.

Information on a single regulating service—water purification—is presented here for illustrative purposes.

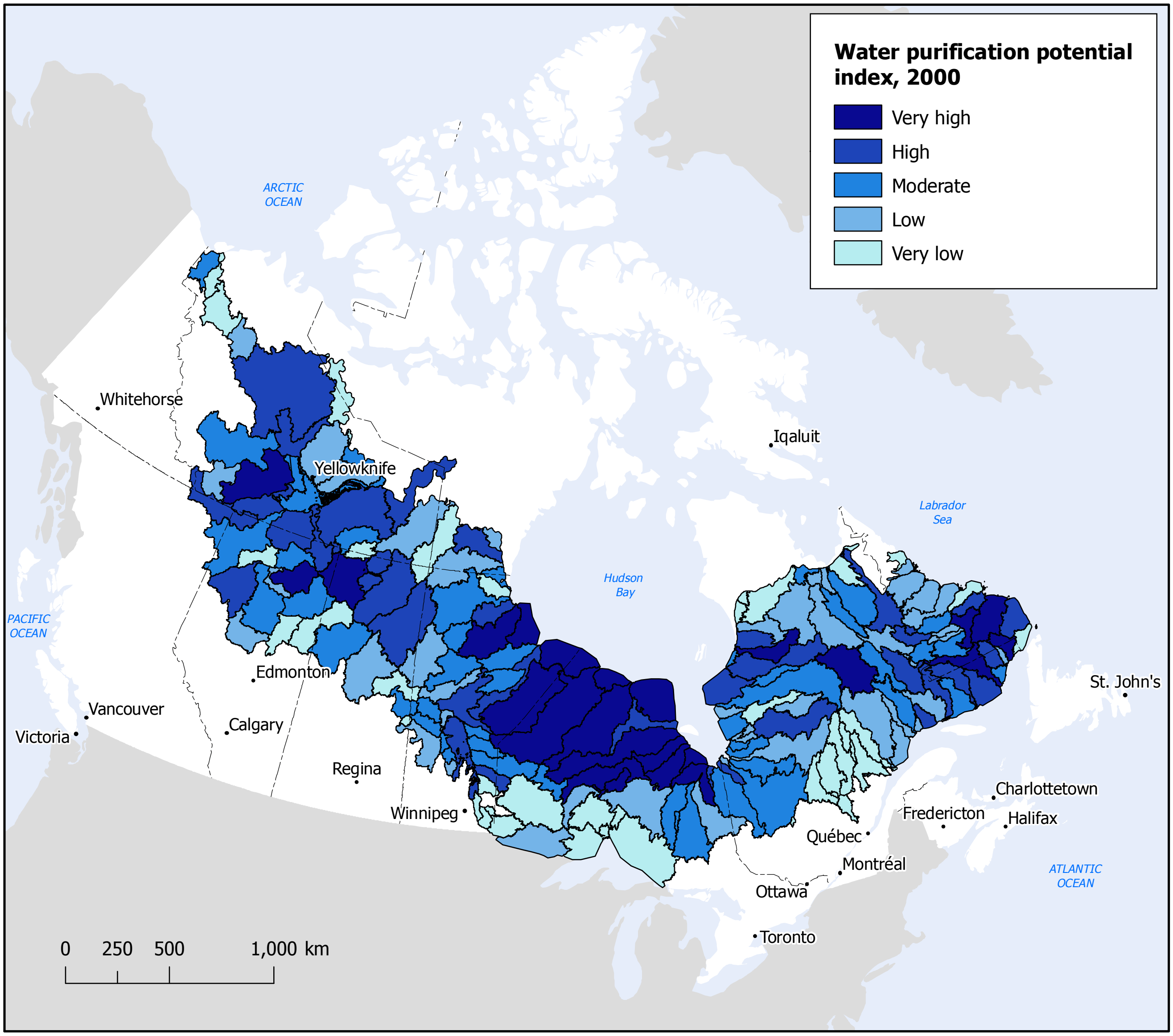
3.3.1 A regulating service: Water purification

Forest ecosystems can affect water quality in many ways. *Riparian* forests provide shade, which moderates water temperatures, and provide a source of organic debris and nutrients, which are used by aquatic organisms. Natural processes in forested areas, such as landslides, channel erosion, blowdown, and wildfire, can affect water quality by increasing sediment and nutrient concentrations and stream temperatures. Forests also modify the chemistry of incoming precipitation as a result of vegetation and soil interactions. Natural disturbances and management activities may change dissolved and chemical particulate concentrations in water bodies.[23]

Water purification is defined as the filtration and decomposition of wastes and pollutants in water, as well as the assimilation and detoxification of compounds through soil and subsoil processes. Preliminary results of the study showed that the potential of boreal *watersheds* to purify water is largely intact, with 71% of the watersheds assessed experiencing no negative change in their water purification potential from 2000 to 2010 (Maps 3.4, 3.5 and 3.6).[24]

19. Bastien, O., D. Haaese and K. Grunewald, 2012, "Ecosystem properties, potentials and services – the EPPS conceptual framework and an urban application example," *Ecological Indicators,* Vol. 21, pages 7 to 16.
20. van Oudenhoven, A.P.E., K. Petz, R. Alkemade, L. Hein and R.S. de Groot, 2012, "Framework for systematic indicator selection to assess effects of land management on ecosystem services," *Ecological Indicators,* Vol. 21, pages 110 to 122.
21. Burkhard. B., F. Kroll, S. Nedkov and F. Müller, 2012, "Mapping ecosystem service supply, demand and budgets," *Ecological Indicators*, Vol. 21, pages 17 to 29.
22. The boreal zone is a major biogeoclimatic zone of the high northern latitudes, covering much of North America, mainly with forests, woodlands, wetlands and lakes (see Maps 3.4, 3.5 and 3.6).
23. Pike, R.G., M.C. Feller, J.D. Stednick, K.V. Rieberger and M. Carver, 2010, "Water Quality and Forest Management," pages 401 to 440 in Pike, R.G., T.E. Redding, R.D. Moore, R.D. Winker and K.D. Bladon (eds.), 2010, *Compendium of forest hydrology and geomorphology in British Columbia*, British Columbia Ministry of Forests and Range, Forest Science Program, Victoria, B.C. and FORREX Forum for Research and Extension in Natural Resources, Kamloops, B.C., Land Management Handbook 66, *www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh66.htm* (accessed March 19, 2013).
24. Results from the boreal forest case study are preliminary. The variability observed in the index values was not assessed against independent datasets on water quality. While the formulation of the index relied on best information available in the scientific literature at the time, the outputs from the boreal case study will require further validation. For further information about the index, interpretation of the results and important caveats, please refer to Appendix D.

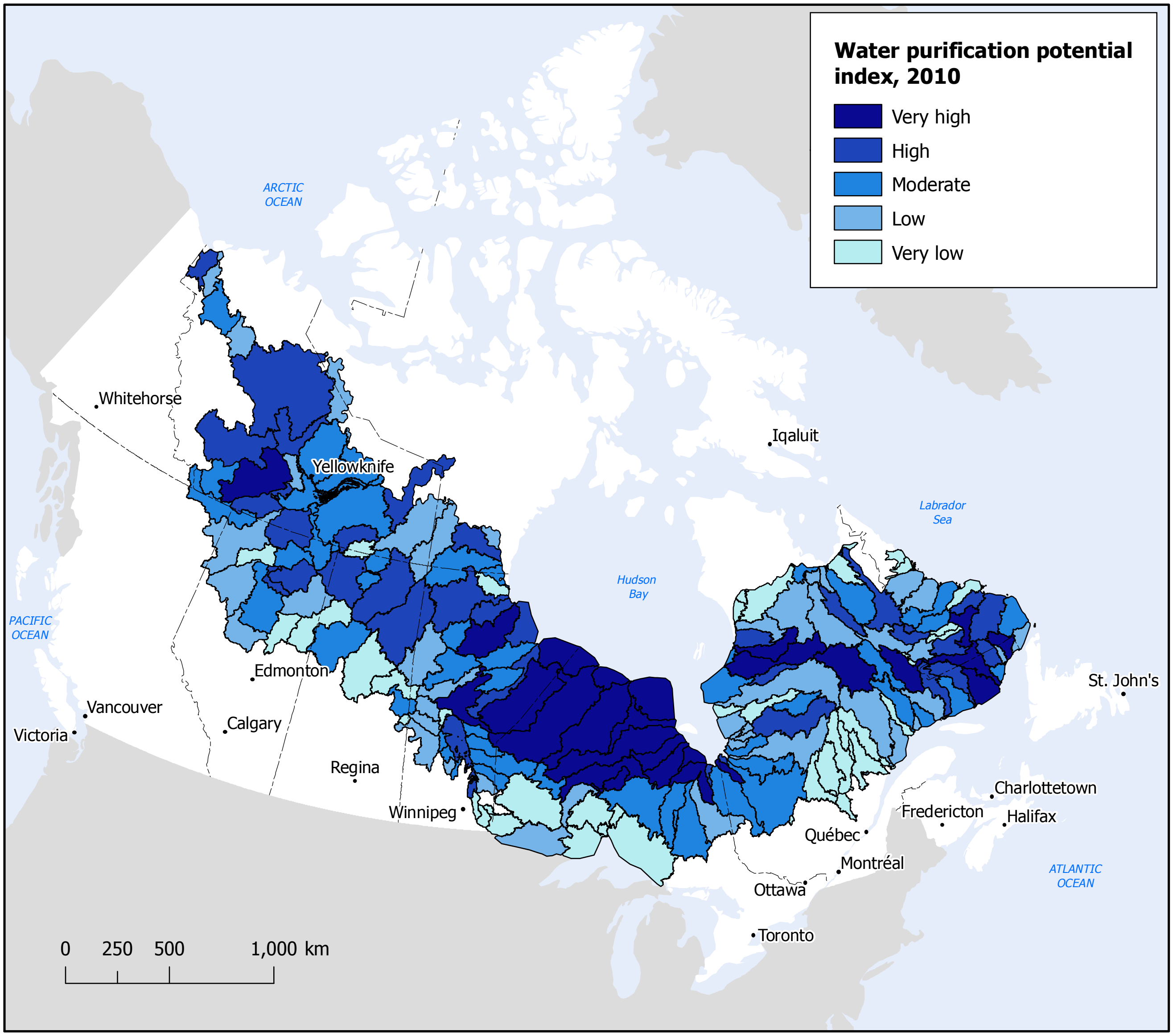
Map 3.4
Water purification potential index by watershed, 2000



Note(s): Results from the boreal forest case study are preliminary. The variability observed in the index values was not assessed against independent datasets on water quality. The selected predictor variables, data sources and scoring scheme are found in Tables 1 and 2 (Appendix D).

Source(s): Environment Canada and Natural Resources Canada, 2013, special tabulation.

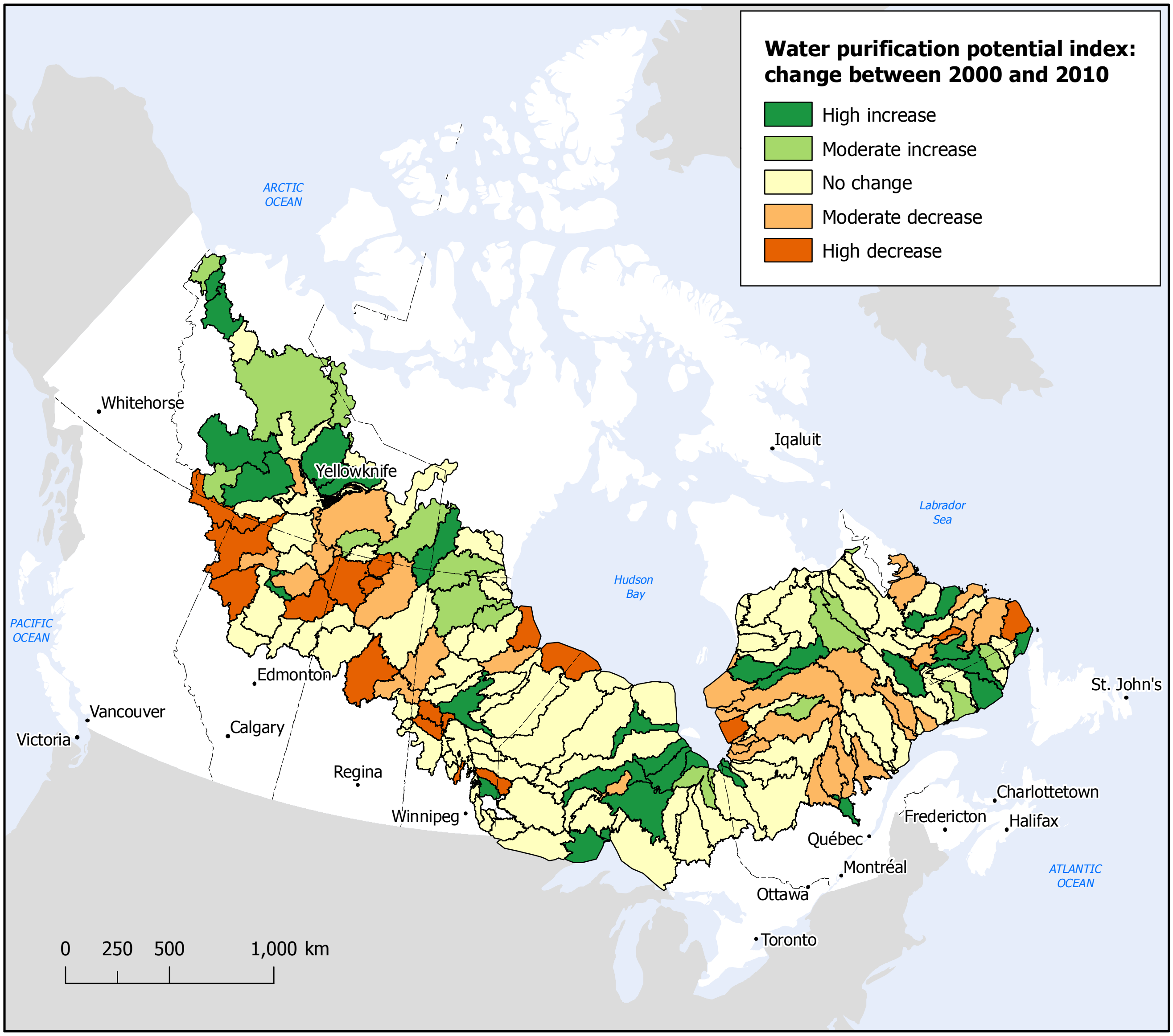
Map 3.5
Water purification potential index by watershed, 2010



Note(s): Results from the boreal forest case study are preliminary. The variability observed in the index values was not assessed against independent datasets on water quality. The selected predictor variables, data sources and scoring scheme are found in Tables 1 and 2 (Appendix D).

Source(s): Environment Canada and Natural Resources Canada, 2013, special tabulation.

Map 3.6
Water purification potential index by watershed, 2000 to 2010 change



Note(s): Results from the boreal forest case study are preliminary. The variability observed in the index values was not assessed against independent datasets on water quality. The selected predictor variables, data sources and scoring scheme are found in Tables 1 and 2 (Appendix D).

Source(s): Environment Canada and Natural Resources Canada, 2013, special tabulation.

While still relatively high, the water purification potential index of watersheds declined from 2000 to 2010 in some regions of the boreal forest, including in the south-west and eastern parts. Underlying causes of these changes varied and included, in no particular order, an increase in the area affected by forest fires, a decrease in forest cover and riparian forest buffer, and an increase in the area affected by settlements and other human landscape features (e.g., roads, powerlines).

3.4 Ecosystem productivity measure: National biomass extraction

Ecosystems have the capacity to provide or contribute to the production of many goods that people use including organic materials such as agricultural products, fish, and timber, which can collectively be referred to as '*biomass*.' The extraction of these goods can place pressure on ecosystems, potentially reducing their ability to produce EGS in the future. For example, overfishing can deplete fish populations upon which people rely as a stock of natural resources; farming and forestry practices can result in soil erosion; and livestock production can degrade the productivity of pasture land and rangeland through overgrazing. Measuring the extraction of biomass is a step towards the development of indicators that help explain whether human use of ecosystem goods is sustainable.[25,26] For more information see Appendix E.

Table 3.5 shows the extraction of biomass for human use for the following categories: agricultural crops, livestock and poultry, milk, maple products and honey, forestry, and fisheries. An estimated 285.8 million tonnes of biomass were extracted for human use from Canada's terrestrial and aquatic ecosystems in 2010. Biomass extraction related to crops was highest in Alberta, Saskatchewan and Ontario. The top three provinces producing livestock and poultry were Quebec, Alberta and Ontario. Quebec and Ontario account for the largest proportion of biomass extraction in the form of milk, maple products and honey.

25. For example, tracking net carbon balance (NCB) provides an assessment of the goods and services that are provided by the earth's ecosystems. NCB is considered an indicator of the sustainability of carbon or biomass use. The MEGS project focused on measuring biomass extraction as it is a component of carbon accounting.
26. Biomass extraction data are provided for various sources (e.g., agricultural crops, livestock and poultry, milk, honey and maple products, forestry, fisheries) but are not a complete representation of all biomass extraction in Canada.

Table 3.5
Biomass extraction for human use from Canada's terrestrial and aquatic ecosystems, by province, by category, 2010

	Agricultural crops [1]	Livestock and poultry [2]	Milk, maple products and honey [3]	Forestry [4]	Fisheries [5]		Total
					Freshwater	Marine	
	tonnes						
Canada, total	**115,550,105**	**4,514,920**	**7,985,038**	**156,616,813**	**187,532**	**951,529**	**285,805,936**
Newfoundland and Labrador	43,892	768	50,916	1,684,873	15,360	...	1,795,809
Prince Edward Island	1,716,771	14,070	104,996	435,530	22,589	...	2,293,956
Nova Scotia	721,972	43,752	175,346	5,031,045	8,118	...	5,980,233
New Brunswick	1,283,261	40,706	141,111	10,348,328	26,783	...	11,840,188
Quebec	12,345,969	1,195,811	2,999,866	19,653,853	1,567	...	36,197,065
Ontario	25,911,380	1,125,865	2,585,206	14,537,498	15,358	...	44,175,306
Manitoba	12,325,410	463,297	325,977	1,431,188	10,934	...	14,556,805
Saskatchewan	29,409,919	272,295	237,846	2,154,078	2,731	...	32,076,869
Alberta	29,484,989	1,152,822	685,836	23,601,685	1,205	...	54,926,536
British Columbia	2,306,541	205,537	677,938	77,681,490	82,435	...	80,953,941
Yukon	..	..	..	30,308	0	...	30,308
Northwest Territories	..	..	..	26,940	28	...	26,968
Nunavut	..	..	..	..	424	...	424
Atlantic Ocean	...	...	...	...	...	799,243	799,243
Pacific Ocean	...	...	...	...	...	152,286	152,286

1. Includes the majority of grains, oilseeds and hay, fruits, vegetables, potatoes, and greenhouse production.
2. Includes cattle, hog, sheep, lamb and poultry production (warm carcass weight). Excludes slaughter of imported animals.
3. Maple products are expressed as syrup.
4. Includes green weight with bark harvests (including industrial roundwood, fuel wood and firewood).
5. Inland data includes aquaculture and freshwater commercial fishing (live weight). Marine fisheries data includes fish and shellfish extraction (live weight). Biomass extraction in recreational fisheries is not included in this table.

Note(s): Biomass extraction represents the amount of organic material produced by or derived from living organisms that humans extract from the environment. Biomass extraction data are provided for various sources, but are not a complete representation of all biomass extraction in Canada. Data here may be underestimated since source data that were suppressed for confidentiality reasons or that were too unreliable to be published were treated as zeros. Some mathematical adjustments were performed to ensure comparability of results

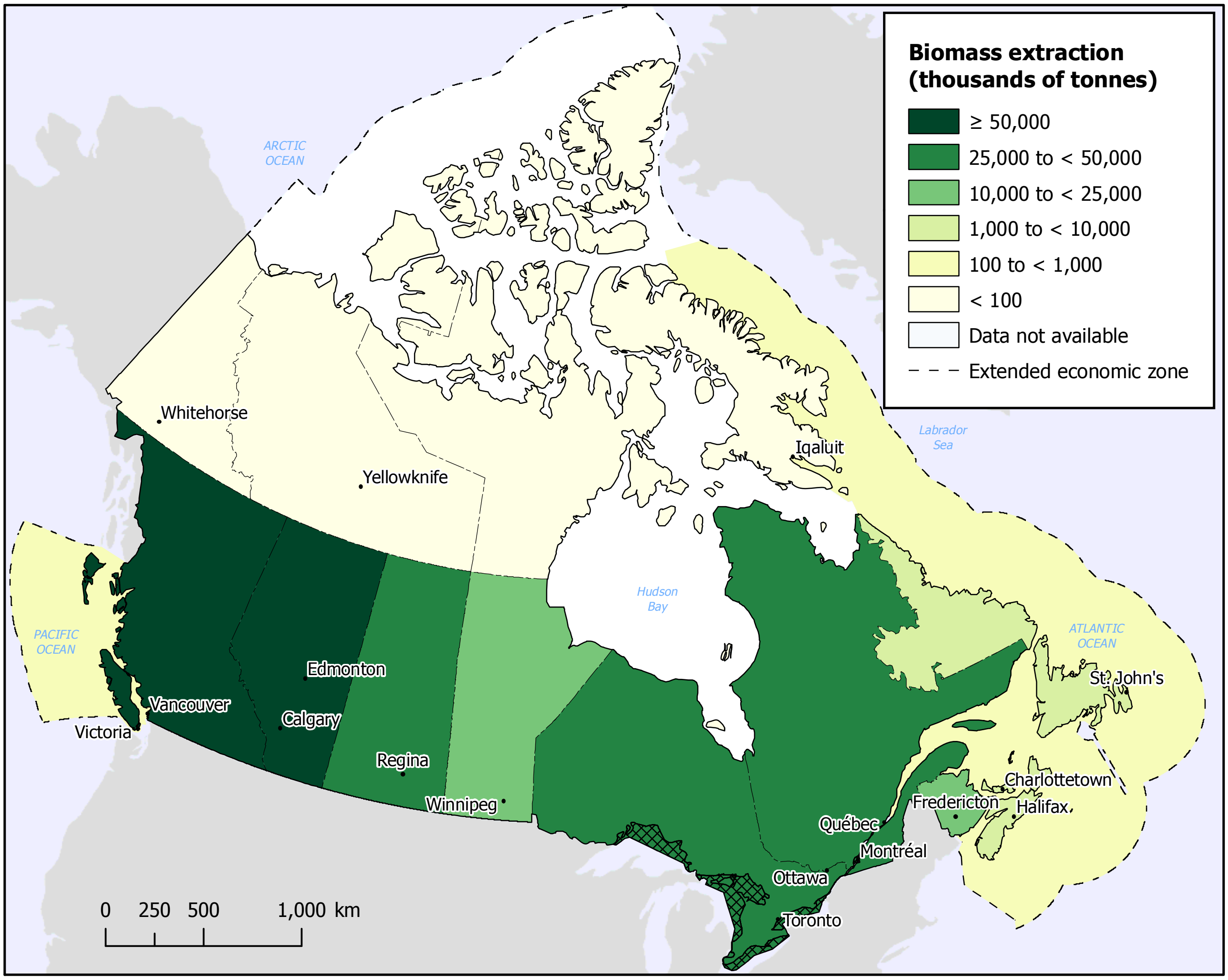
Source(s): Statistics Canada, CANSIM tables 001-0006, 001-0009, 001-0010, 001-0013, 001-0014, 003-0001, 003-0011, 003-0018 (accessed February 7, 2013), 003-0094 and 003-0083 (accessed May 9, 2013). Statistics Canada, 2011, *Production and Value of Honey and Maple Products, 2011*, Catalogue no. 23-221-X. Fisheries and Oceans Canada, 2012, *Freshwater Fisheries - Catches and Landed Values by Species, By Province/Territory, 2010*, *www.dfo-mpo.gc.ca/stats/commercial/land-debarq/freshwater-eaudouce/2010-eng.htm* (accessed February 7, 2013). Fisheries and Oceans Canada, 2012, *Seafisheries, Landings, Commercial Fisheries*, *http://dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm* (accessed February 5, 2013). Natural Resources Canada, 2012, *The State of Canada's Forests: Annual Report 2012*, Catalogue no. Fo1-6/2012E-PDF, *http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/34055.pdf* (accessed February 7, 2013). United Nations Economic Commission for Europe and the Food and Agriculture Organization of the United Nations, 2010, *Forest Product Conversion Factors for the UNECE Region*, Geneva Timber and Forest Discussion Paper 49, *www.unece.org/fileadmin/DAM/timber/publications/DP-49.pdf* (accessed February 7, 2013). Agriculture and Agri-Food Canada, 2012, *009D Average Warm Carcass Weights at Federally Inspected Plants*, *http://www3.agr.gc.ca/apps/aimis-simia/rp/index-eng.cfm?menupos=1.02.08&PARENT_DATA_CLCTN_TYPE_CODE=&REPORT_ID=135&ACTION=promptReport&LANG=EN* (accessed May 7, 2013). Food and Agriculture Organization of the United Nations (FAO) and the Information Network on Post-harvest Operations (INPhO), 1998, "Chapitre 2 Laits d'animaux laitiers,"*Le lait et les produits laitiers dans la nutrition humaine*, *www.fao.org/docrep/t4280f/T4280F04.htm#Chapitre* (accessed August 14, 2013). Wikipedia, 2013, *Masse volumique*, *http://fr.wikipedia.org/wiki/Masse_volumique* (accessed August 14, 2013). Agriculture and Agri-Food Canada, 2007, *Canadian Maple Products Situation and Trends 2006-2007*, *http://www5.agr.gc.ca/resources/prod/doc/misb/hort/sit/pdf/maple_2006-07_e.pdf* (accessed August 14, 2013).

Half of Canada's forest biomass extraction came from British Columbia, followed by Alberta (15%) and Quebec (13%). Coastal fisheries accounted for the majority of Canada's total biomass extraction from commercial fisheries, with the vast majority coming from the Atlantic provinces.

The largest proportion of biomass extraction occurred in British Columbia, as a result of the importance of forestry (Map 3.7). While proportionally less biomass was extracted in marine and coastal areas, this result can be attributed to the lower relative contribution of fisheries to total biomass extraction compared to agriculture and forestry. Comparatively little biomass extraction took place in Canada's North.

Map 3.7

Biomass extraction for human use from Canada's terrestrial and aquatic ecosystems, 2010



Note(s): Biomass extraction represents the amount of organic material produced by or derived from living organisms that humans extract from the environment. Biomass extraction data are provided for various sources, but are not a complete representation of all biomass extraction in Canada. Data here may be underestimated since source data that were suppressed for confidentiality reasons or that were too unreliable to be published were treated as zeros. Some mathematical adjustments were performed to ensure comparability of results. This map includes biomass from the following categories: agricultural crops; livestock and poultry; milk, maple products and honey; forestry; and fisheries. Agricultural crops include the majority of grains, oilseeds and hay, fruits, vegetables, potatoes, and greenhouse production. Livestock and poultry include cattle, hog, sheep, lamb and poultry production (warm carcass weight) and exclude slaughter of imported animals. Maple products are expressed as syrup. Forestry data include green weight with bark harvests (including industrial roundwood, fuel wood and firewood). Inland fisheries data include aquaculture and freshwater commercial fishing (live weight). Marine fisheries data include fish and shellfish extraction (live weight). Biomass extraction in recreational fisheries is not included in this map.

Source(s): Statistics Canada, CANSIM tables 001-0006, 001-0009, 001-0010, 001-0013, 001-0014, 003-0001, 003-0011, 003-0018 (accessed February 7, 2013), 003-0094 and 003-0083 (accessed May 9, 2013). Statistics Canada, 2011, *Production and Value of Honey and Maple Products, 2011*, Catalogue no. 23-221-X. Fisheries and Oceans Canada, 2012, *Freshwater Fisheries - Catches and Landed Values by Species, By Province/Territory, 2010*, www.dfo-mpo.gc.ca/stats/commercial/land-debarq/freshwater-eaudouce/2010-eng.htm (accessed February 7, 2013). Fisheries and Oceans Canada, 2012, *Seafisheries, Landings, Commercial Fisheries*, http://dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm (accessed February 5, 2013). Natural Resources Canada, 2012, *The State of Canada's Forests: Annual Report 2012*, Catalogue no. Fo1-6/2012E-PDF, http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/34055.pdf (accessed February 7, 2013). United Nations Economic Commission for Europe and the Food and Agriculture Organization of the United Nations, 2010, *Forest Product Conversion Factors for the UNECE Region*, Geneva Timber and Forest Discussion Paper 49, www.unece.org/fileadmin/DAM/timber/publications/DP-49.pdf (accessed February 7, 2013). Agriculture and Agri-Food Canada, 2012, *009D Average Warm Carcass Weights at Federally Inspected Plants*, http://www3.agr.gc.ca/apps/aimis-simia/rp/index-eng.cfm?menupos=1.02.08&PARENT_DATA_CLCTN_TYPE_CODE=&REPORT_ID=135&ACTION=promptReport&LANG=EN (accessed May 7, 2013). Food and Agriculture Organization of the United Nations (FAO) and the Information Network on Post-harvest Operations (INPhO), 1998, "Chapitre 2 Laits d'animaux laitiers," *Le lait et les produits laitiers dans la nutrition humaine*, www.fao.org/docrep/t4280f/T4280F04.htm#Chapitre (accessed August 14, 2013). Wikipedia, 2013, *Masse volumique*, http://fr.wikipedia.org/wiki/Masse_volumique (accessed August 14, 2013). Agriculture and Agri-Food Canada, 2007, *Canadian Maple Products Situation and Trends 2006-2007*, http://www5.agr.gc.ca/resources/prod/doc/misb/hort/sit/pdf/maple_2006-07_e.pdf (accessed August 14, 2013).

3.5 Marine and coastal ecosystem goods and services

Oceans and coasts may provide as much as two-thirds of the planet's ecosystem services.[27] However, marine and coastal ecosystems worldwide face many threats, including overfishing, coastal development and impacts related to climate change and ocean acidification.[28] Given the many gaps in knowledge about marine ecosystems, there is a high level of concern about the cumulative effects of these issues and their impacts

27. Beaudoin, Y. and L. Pendleton (eds.), 2012, *Why value the oceans? A discussion paper*, UNEP/GRID-Arendal, Duke University's Nicholas Institute for Environmental Policy Solutions, The Economics of Ecosystems and Biodiversity and the UNEP Regional Seas Programme.

28. Fisheries and Oceans Canada, 2012, *Canada's State of the Oceans Report*, *www.dfo-mpo.gc.ca/science/coe-cde/soto/documents/dfo_soto/english/index-eng.htm* (accessed June 14, 2013).

Textbox 2: Marine and coastal areas

Canada's marine and coastal waters cover about 5.6 million km^2,[29] equivalent to about 56% of Canada's land mass. They have been classified into 12 ecoregions based on oceanographic and depth similarities and general ecological features (see Appendix H). At finer scales there is a wide variety of ecosystem types, ranging from estuaries, bays, fjords and other coastal areas, continental shelves and slopes, and the open ocean.

There is a great deal of diversity in what can be found in any given area of the ocean, from below the seafloor to above the surface. Marine areas have characteristic patterns of temperature and chemistry, as well as predictable currents and tides. These characteristics will influence the types of organisms that live in each area including seagrasses and other marine plants; corals, sponges and other invertebrates like sea urchins and starfish on or near the bottom; phytoplankton and zooplankton, fish, and marine mammals such as seals, dolphins and whales; and seabirds in the land, water and air. These different parts and aspects of the ecosystem interact and influence each other, through predation, provision of shelter and competition for space and food.

Marine EGS depend on healthy marine ecosystem components, processes and functions. For example, fisheries rely on the structures and processes required to support productive fish populations, including reproduction, growth, survivorship, and availability of both the harvested fish and their prey. The oceans' *carbon cycle* relies on the dissolution and release of atmospheric carbon dioxide in the water, as well as on the absorption and release of carbon by marine plants—how these factors balance one another determines whether the oceans are a source or sink of atmospheric carbon dioxide. Recreational values may depend on the presence of fish species that people enjoy catching or on the diversity of life that can be seen when diving in coastal waters.

An important characteristic of marine ecosystems and their goods and services is the degree to which they are interconnected. Fishing that depletes one type of fish is likely to have indirect effects on other species as a result of numerous ecological relationships. Some fishing methods negatively impact marine habitats, undermining their productive potential and also potentially affecting other EGS. Higher levels of carbon dioxide in the ocean make it more acidic, which can impact shellfish[30] and can also create anoxic conditions, potentially leading to fish kills.[31]

on ecosystem components and functions, and on the provision of EGS.

Fish—perhaps the best known provisioning service—can be captured for direct human consumption and to a lesser extent for animal feed. Fish are also increasingly farmed for human consumption.

Marine and coastal ecosystems also play an important role in regulating global climate both because of the ocean's role in storing and moving heat, and because much of the carbon dioxide emitted into the atmosphere from burning fossil fuels and other sources eventually enters the ocean.[32] Oceans also dilute and store sewage and other waste products, while seagrasses and shoreline vegetation protect coastlines from erosion.[33]

Cultural services with substantial economic benefits including camping, boating, fishing, diving and whale watching are also obtained from marine and coastal ecosystems. Other cultural services include the heritage value attached to the oceans and people's interactions with them.

While many important EGS are obtained from the oceans, few data are available, with the exception of commercial fishery catches.[34] In 2011, commercial fish landings on Canada's Atlantic and Pacific coasts totalled over 850,000 tonnes (Table 3.6). Two-thirds of the landed weight originated from relatively few areas (Maps 3.8 and 3.9).

29. This figure excludes the extended continental shelf. See: Fisheries and Oceans Canada, 2013, *Canada's Ocean Estate: A Description of Canada's Maritime Zones*, *www.dfo-mpo.gc.ca/oceans/canadasoceans-oceansducanada/marinezones-zonesmarines-eng.htm* (accessed June 14, 2013).
30. Fisheries and Oceans Canada, 2013, *Canada's State of the Oceans Report*, *www.dfo-mpo.gc.ca/science/coe-cde/soto/report-rapport-2012/index-eng.asp* (accessed July 11, 2013).
31. Fisheries and Oceans Canada, 2013.
32. Terrados, J. and J. Borum, 2004, "Why are seagrasses important? – Goods and services provided by seagrass meadows," pages 8 to 10 in Borum, J., C.M. Duarte, D. Krause-Jensen and T.M. Greve (eds.), 2004, *European seagrasses: an introduction to monitoring and management,* Monitoring and Managing of European Seagrasses (M&MS) project.
33. Terrados and Borum, 2004.
34. Comprehensive fisheries data are not available for aboriginal, subsistence or recreational fisheries.

Table 3.6
Landed weight and value of commercial sea fisheries, 2006 to 2011

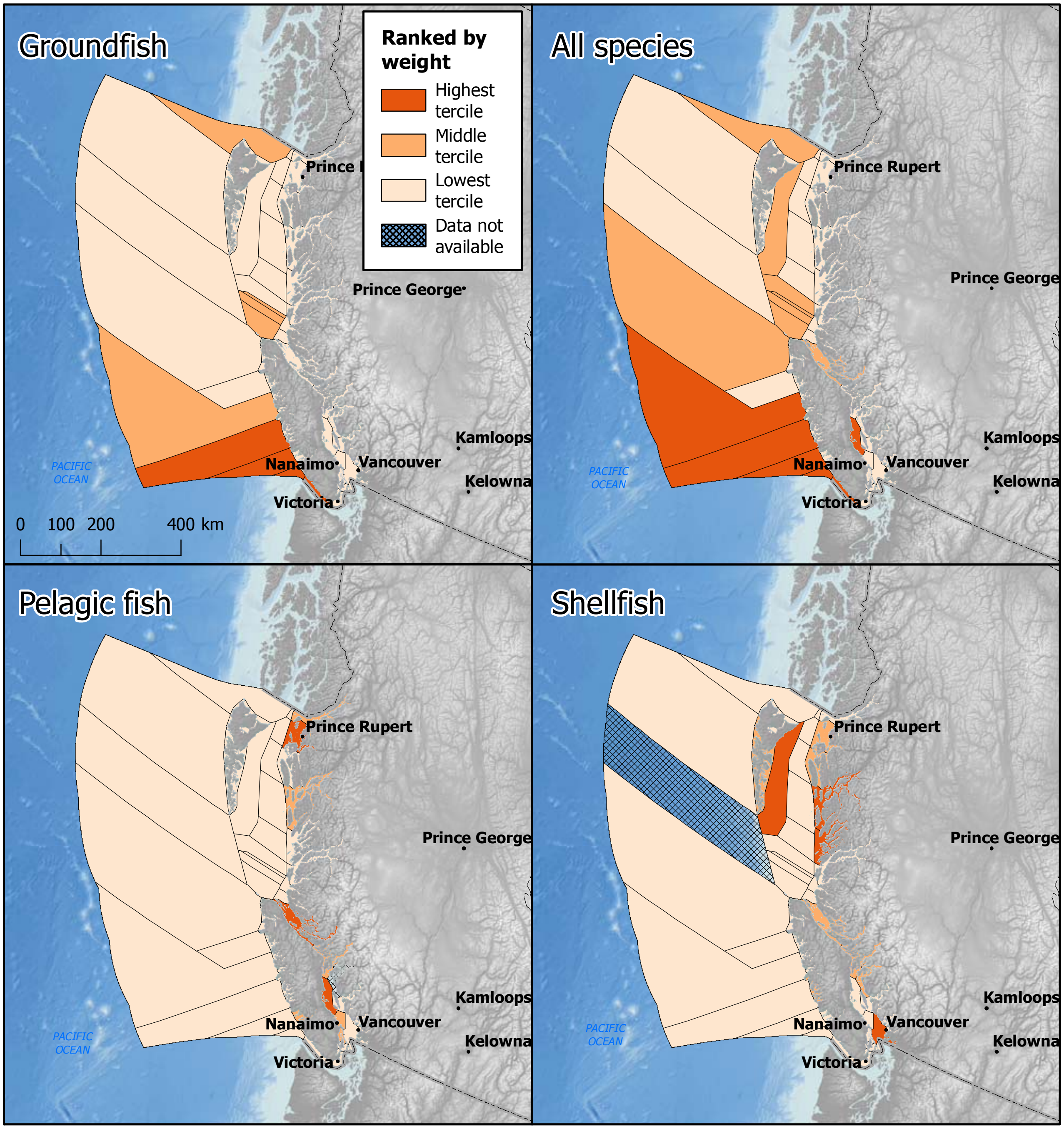
	2006		2007		2008		2009		2010		2011	
	tonnes (live weight)	thousands of dollars	tonnes (live weight)	thousands of dollars	tonnes (live weight)	thousands of dollars	tonnes (live weight)	thousands of dollars	tonnes (live weight)	thousands of dollars	tonnes (live weight)	thousands of dollars
Total	**1,090,407**	**1,921,127**	**1,012,153**	**1,976,017**	**937,112**	**1,905,391**	**960,231**	**1,702,397**	**951,529**	**1,825,589**	**850,533**	**2,107,402**
Groundfish	**258,637**	**314,743**	**231,890**	**293,150**	**226,060**	**272,371**	**203,865**	**263,401**	**191,162**	**266,984**	**178,591**	**269,571**
Cod	28,371	38,446	27,263	43,646	27,199	45,537	20,912	26,138	19,276	21,807	14,909	19,070
Haddock	16,960	26,848	19,238	27,656	20,539	26,561	23,395	36,921	22,401	30,017	15,201	26,079
Redfish spp.	32,642	34,857	27,931	28,322	25,537	24,436	30,215	26,931	31,213	27,723	31,839	29,323
Halibut	9,109	71,182	7,992	69,464	6,849	55,247	6,458	53,487	6,629	60,051	6,667	65,408
Flatfishes	16,737	13,971	18,080	13,832	23,160	16,826	16,619	12,734	18,342	14,322	18,344	12,985
Greenland turbot	14,623	36,422	13,698	32,182	12,171	24,434	13,709	41,721	14,714	57,596	13,946	59,966
Pollock	8,010	4,951	10,126	6,183	7,112	5,183	8,880	5,664	9,036	6,341	9,575	6,383
Hake	112,612	38,821	88,810	33,615	89,408	37,611	68,830	24,357	58,655	19,997	56,739	20,359
Cusk	883	787	1,046	982	613	592	578	560	474	416	469	463
Catfish	69	29	73	37	4	3	0 s	0 s	8	5	0 s	0 s
Skate	2,703	757	2,735	1,775	1,996	1,094	2,045	906	1,495	1,064	2,075	1,529
Dogfish	4,857	4,631	6,478	3,665	3,728	1,914	4,455	2,816	1,847	1,045	1,086	568
Other	11,060	43,043	8,421	31,790	7,745	32,933	7,768	31,166	7,072	26,599	7,740	27,438
Pelagic and other finfish	**318,611**	**194,768**	**304,998**	**160,446**	**243,440**	**139,543**	**286,213**	**142,558**	**274,527**	**190,427**	**230,170**	**164,349**
Herring	183,471	53,548	179,775	56,902	151,766	47,333	167,504	60,693	159,411	50,515	142,052	40,801
Mackerel	53,959	20,473	53,394	17,738	29,672	11,885	42,231	15,671	38,738	18,458	11,397	10,817
Swordfish	1,405	11,897	1,348	11,378	1,383	8,803	1,299	7,710	1,346	10,457	1,554	10,613
Tuna	6,002	28,371	6,111	24,134	4,536	25,861	5,070	21,689	5,737	26,720	5,224	34,834
Alewife	4,398	2,016	3,453	2,078	3,682	2,062	3,243	1,854	2,765	1,355	2,213	1,513
Eel	417	2,837	383	4,339	253	8,962	251	1,038	280	1,243	281	1,717
Salmon	24,287	61,532	20,234	31,670	5,390	21,773	18,507	23,724	23,568	70,652	20,670	47,939
Smelt	927	741	822	664	797	552	954	1,041	620	468	390	436
Silversides	551	615	495	427	444	407	488	479	689	805	325	312
Shark	273	247	177	180	179	170	122	207	135	229	74	127
Capelin	42,194	11,695	37,599	10,067	39,175	10,075	35,359	5,390	26,527	3,199	32,448	5,703
Other	727	796	1,209	868	6,163	1,661	11,185	3,063	14,712	6,324	13,542	9,536
Shellfish	**466,104**	**1,368,848**	**452,828**	**1,501,503**	**447,297**	**1,476,015**	**423,955**	**1,283,364**	**439,670**	**1,352,174**	**423,846**	**1,659,837**
Clams or quahaugs	28,985	71,306	24,692	64,873	24,956	60,072	31,647	84,989	28,641	75,467	28,598	77,985
Oyster [1]	2,405	7,163	2,355	6,791	1,684	4,161	2,168	5,436	1,934	4,867	1,877	4,943
Scallop [2]	63,407	87,922	65,351	89,608	67,634	92,902	62,932	88,087	60,316	82,810	59,876	94,009
Squid	6,923	2,915	244	108	527	230	687	275	117	57	129	102
Mussel [3]	151	225	318	407	127	192	54	81	50	93	26	28
Lobster	55,008	653,085	48,870	629,055	58,984	619,451	58,342	507,292	67,277	575,992	66,500	619,739
Shrimp	179,149	236,759	188,216	260,079	167,072	259,665	138,549	192,229	164,784	255,497	151,262	313,623
Crab, Queen	89,646	215,480	90,672	367,551	93,868	357,087	97,308	313,132	84,642	281,426	84,139	459,147
Crab, Other	13,022	28,590	15,523	41,684	14,583	43,192	12,749	39,231	11,990	38,054	10,073	33,400
Whelks	5,792	5,723	5,290	5,154	7,219	7,894	6,501	5,988	7,060	6,566	7,500	9,421
Cockles	10,362	11,209	1,144	1,237	125	143	1,123	1,523	894	1,065	998	1,262
Sea cucumber	3,459	2,741	3,152	2,670	4,516	4,044	5,141	3,979	5,681	5,718	6,756	5,978
Sea urchin	5,382	8,247	4,435	6,859	4,157	7,286	3,876	7,615	4,357	6,219	3,732	7,309
Other	2,413	37,482	2,566	25,426	1,847	19,696	2,878	33,507	1,925	18,343	2,379	32,890
Others	**47,055**	**42,768**	**22,437**	**20,918**	**20,314**	**17,462**	**46,199**	**13,075**	**46,170**	**16,004**	**17,927**	**13,645**
Marine plants	43,191	4,911	19,382	2,448	17,715	2,482	43,300	1,408	43,431	3,814	14,881	1,536
Lumpfish roe	1,135	2,252	454	1,948	294	2,363	80	701	149	1,381	86	709
Miscellaneous	2,729	35,605	2,602	16,522	2,305	12,617	2,819	10,966	2,589	10,810	2,961	11,400

1. Data for British Columbia are reported under aquaculture and are not included in this table. Atlantic data include wild and farmed oysters.
2. Includes meat with roe.
3. PEI mussels are classified under aquaculture and are not included in this table.

Note(s): Figures may not add up to totals due to rounding.

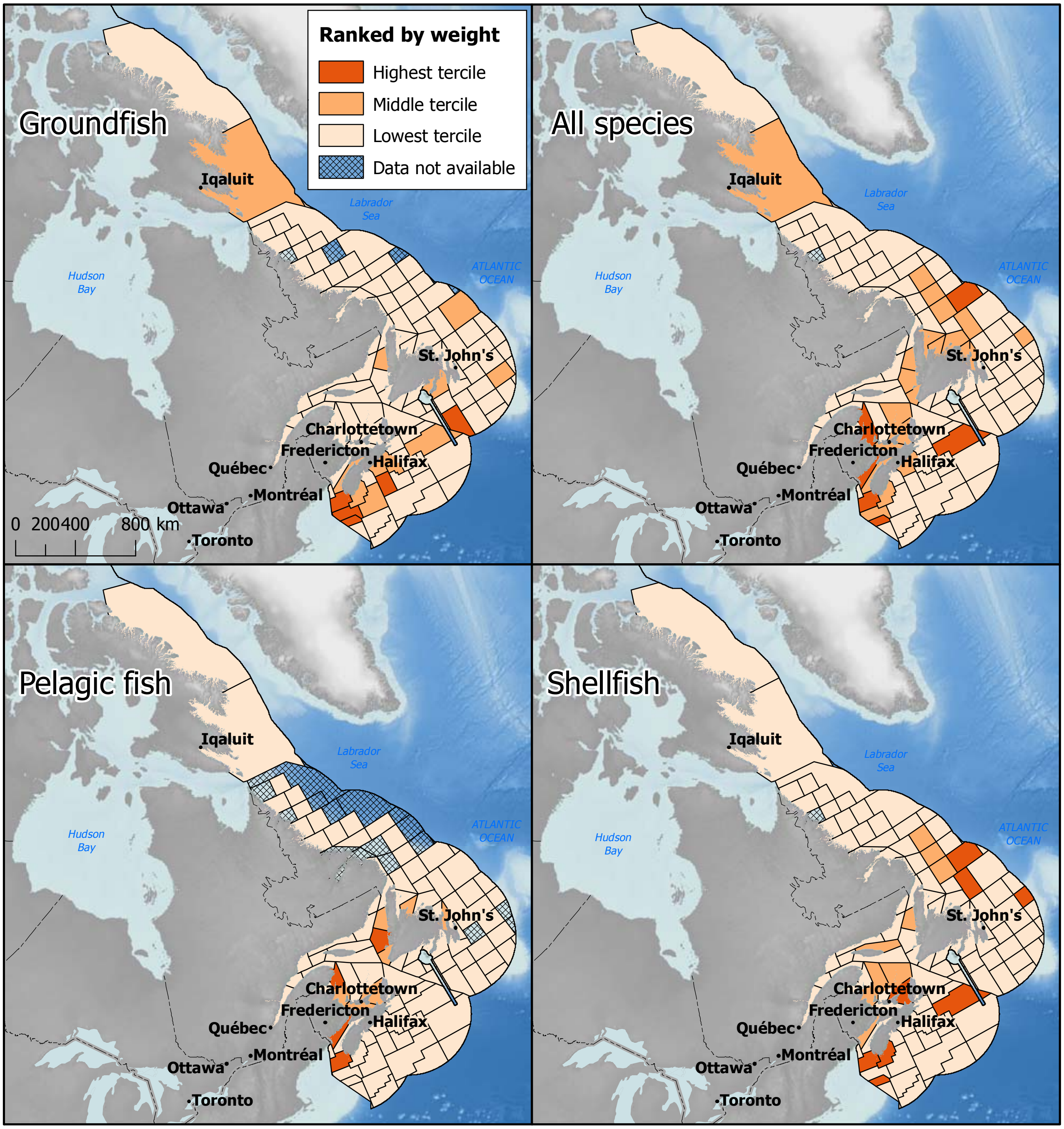
Source(s): Fisheries and Oceans Canada, 2012, *Seafisheries, Landings, Commercial Fisheries,http://dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm* (accessed February 5, 2013).

Map 3.8
Weight of commercial landings, Pacific coast, by statistical area 2006 to 2010



Source(s): Fisheries and Oceans Canada, Economic Analysis and Statistics, Strategic Policy Sector, 2012. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Map 3.9
Weight of commercial landings, Atlantic coast, by statistical area 2006 to 2010



Source(s): Fisheries and Oceans Canada, Economic Analysis and Statistics, Strategic Policy Sector, 2012. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Characterization of spatial relationships is important in understanding marine and coastal EGS. Areas with low landed weight can still be important to the well-being of a species being fished. Salmon, for example, hatch in rivers, sometimes hundreds of kilometres from the ocean, but spend much of their adult life feeding and growing in the ocean before returning to the same river to spawn. Species such as mussels spend most of their life in the same place, but their eggs and larval forms may drift for hundreds of kilometres before settling on the ocean bottom, while the food they filter from the water can also come from quite far away. These examples show how impacts on the ecosystem, such as pollution, can originate in one area but have significant effects on fish populations elsewhere.

Understanding spatial relationships is important for other marine and coastal EGS as well. Recreational services may be enjoyed more in highly populated areas where they are accessible to more people. However, pollution from distant sources can be transported into these recreational areas by ocean currents, affecting the enjoyment of the services by local residents and visitors. Other services, such as carbon sequestration, are provided by ecosystems distributed over a wider area, and the benefits are also more widely distributed.

Data that would allow assessment of the status of marine and coastal ecosystems and EGS are sparse. However, for commercial fisheries, relevant data exist because scientists and managers monitor and assess the status of fish stocks against benchmarks (e.g., healthy, cautious or critical status). In 2011, a summary of the status of 155 major Canadian fish stocks classified 46% as healthy, 20% as cautious, and 11% as critical, while the status of the remaining 23% of fish stocks was unknown.[35]

35. Environment Canada, 2013, *Status of Major Fish Stocks*, *www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=1BCD421B-1#fs1* (accessed July 9, 2013).

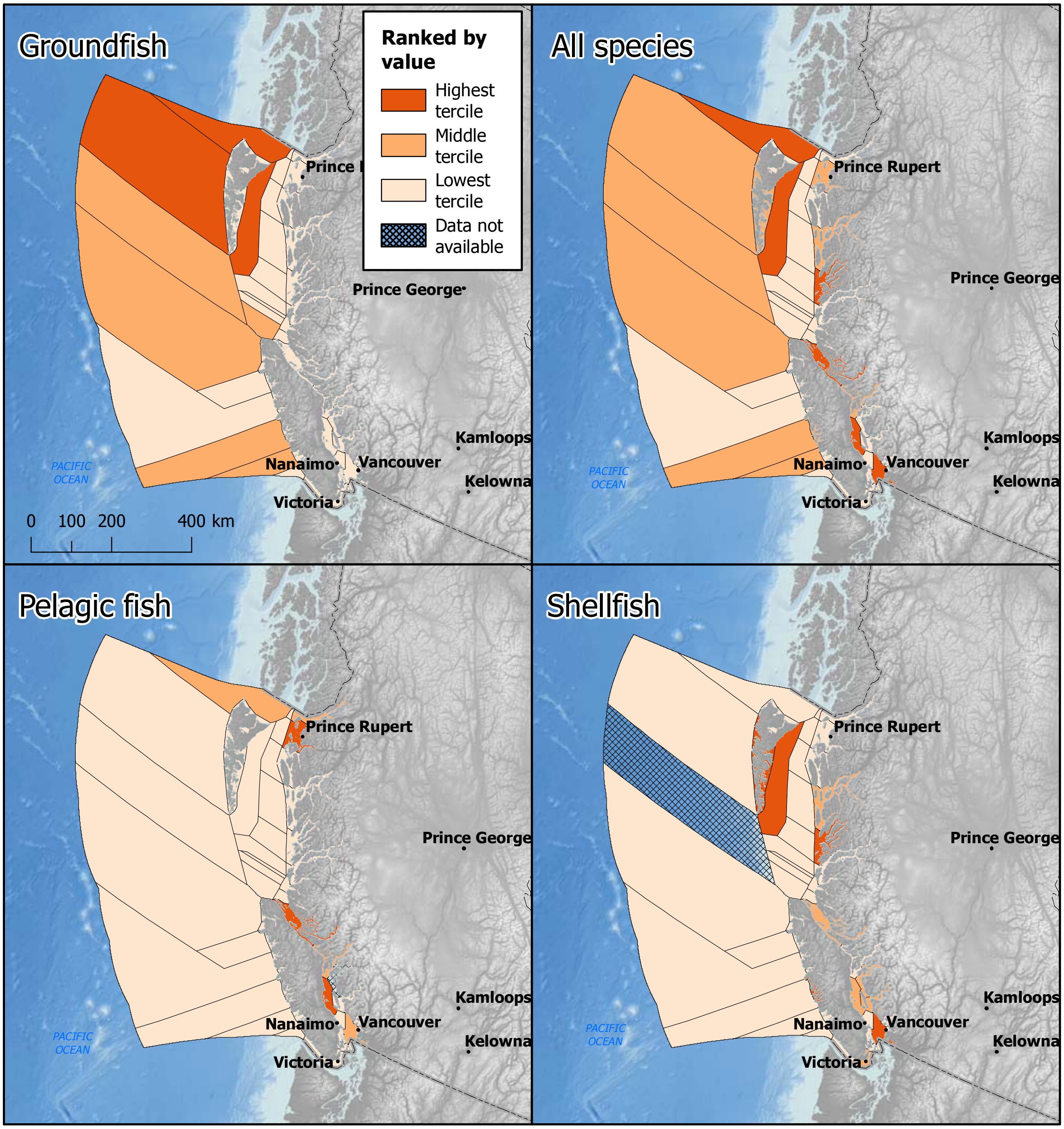
3.5.1 Valuation of marine and coastal ecosystem goods and services

Each marine and coastal area may provide a wide range and quantity of EGS. Many are intermediate goods in a chain of production leading to a final good or service, and much work remains to untangle this web and produce sound monetary value estimates. A number of methods could be applied to assess values of these EGS (Appendix B).

Commercial fisheries catch is almost always associated with markets and financial transactions, and can therefore be tracked. On the other hand, other services provided by marine and coastal areas are usually not associated with markets. Explicit prices are therefore not observed through payment by beneficiaries; in fact, beneficiaries may not even be aware that they are benefiting.

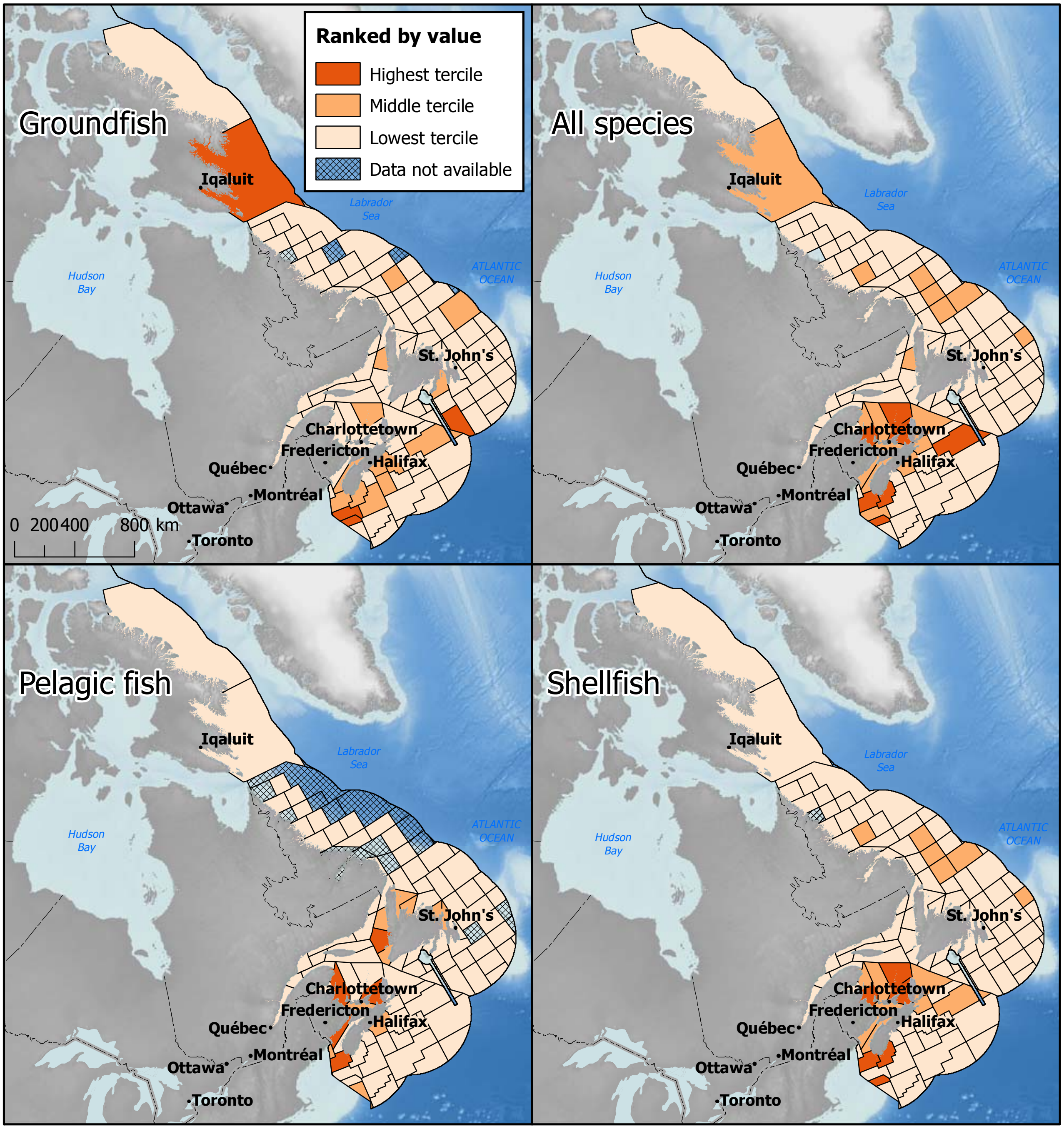
In 2011, commercial fishery landings were valued at $2.1 billion (Table 3.6). Maps 3.10 and 3.11 show the areas in Canada's Pacific and Atlantic waters where the greatest value is generated from these fisheries. The value of the fishery is unevenly distributed geographically, with the specific areas of concentration differing for each species group. Because of differences in market value for fish, lobster, crab and other species, the areas of highest value are not always the same as those accounting for the largest portion of landed weight. In addition, in some coastal areas, even a comparatively small landed value may be critical to the local economy.

Map 3.10
Value of commercial landings, Pacific coast, by statistical area, 2006 to 2010



Source(s): Fisheries and Oceans Canada, Economic Analysis and Statistics, Strategic Policy Sector, 2012. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Map 3.11
Value of commercial landings, Atlantic coast, by statistical area, 2006 to 2010



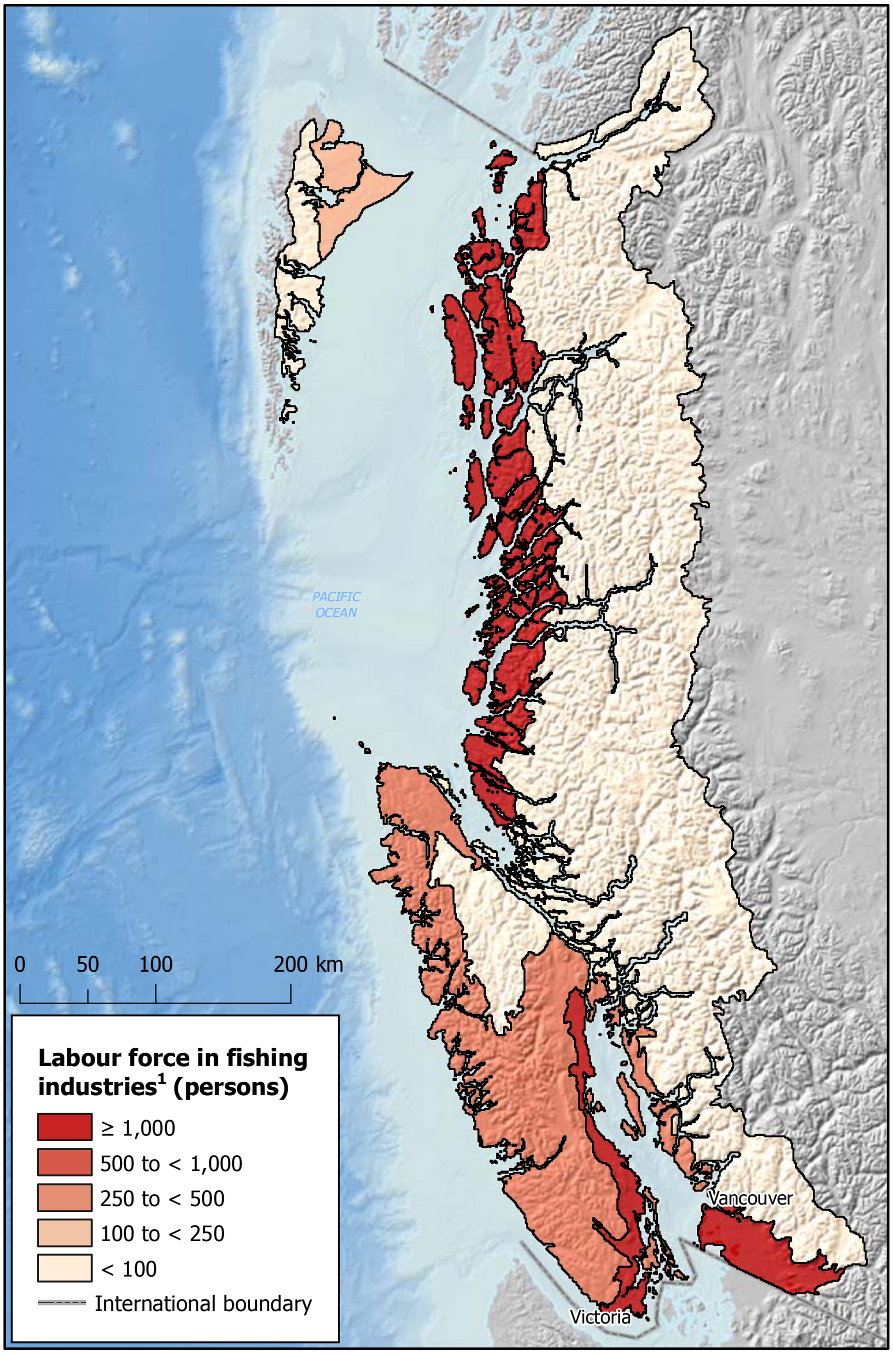
Source(s): Fisheries and Oceans Canada, Economic Analysis and Statistics, Strategic Policy Sector, 2012. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Recreational fisheries offer another example of a service for which monetary value estimates are available—anglers' direct expenditures for fishing trips in 2010 totalled $2.5 billion.[36] While much of this total was for freshwater fishing, expenditures on marine fishing trips in British Columbia alone totalled $368 million with a further $338 million spent on major purchases and investments wholly attributable to marine recreational fishing in the province.[37] A portion of these values is attributable to the fish themselves, but the value is also partly attributable to other aspects of the recreational fishing experience, some of which also rely in part on EGS.

36. Fisheries and Oceans Canada, 2013, *2010 Survey of Recreational Fishing*, *www.dfo-mpo.gc.ca/stats/rec/can/2010/index-eng.htm* (accessed July 9, 2013).
37. Fisheries and Oceans Canada, 2013.
38. Ecodistricts are characterized by distinctive assemblages of relief, fauna, water bodies, soils, landforms and geology and are the lowest level in the Ecological Framework of Canada hierarchy. See Appendix H for more information on geographical units used in this analysis.
39. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 2006 Census of Population.

Marine and coastal EGS provide benefits at many scales—these services range from recreational fishing in local waters to the critical carbon sequestration services provided by oceans at a global scale. Some beneficiaries have a more direct interest in the sound management of coastal and marine ecosystem assets since these assets directly support livelihoods through harvesting and processing activities. Maps 3.12 and 3.13 present the Canadian marine coastal fisheries *ecumene*. They focus on coastal areas at the ecodistrict level,[38] in which selected employment activities related to the marine environment—commercial fishing, aquaculture and seafood processing—are found. On the East coast, in 2006, these activities represented 14% of employment in those communities where the activities were present, compared with 4% on the West Coast (Table 3.7). In some of the smaller communities, these activities represented a third to nearly half of the employment.[39]

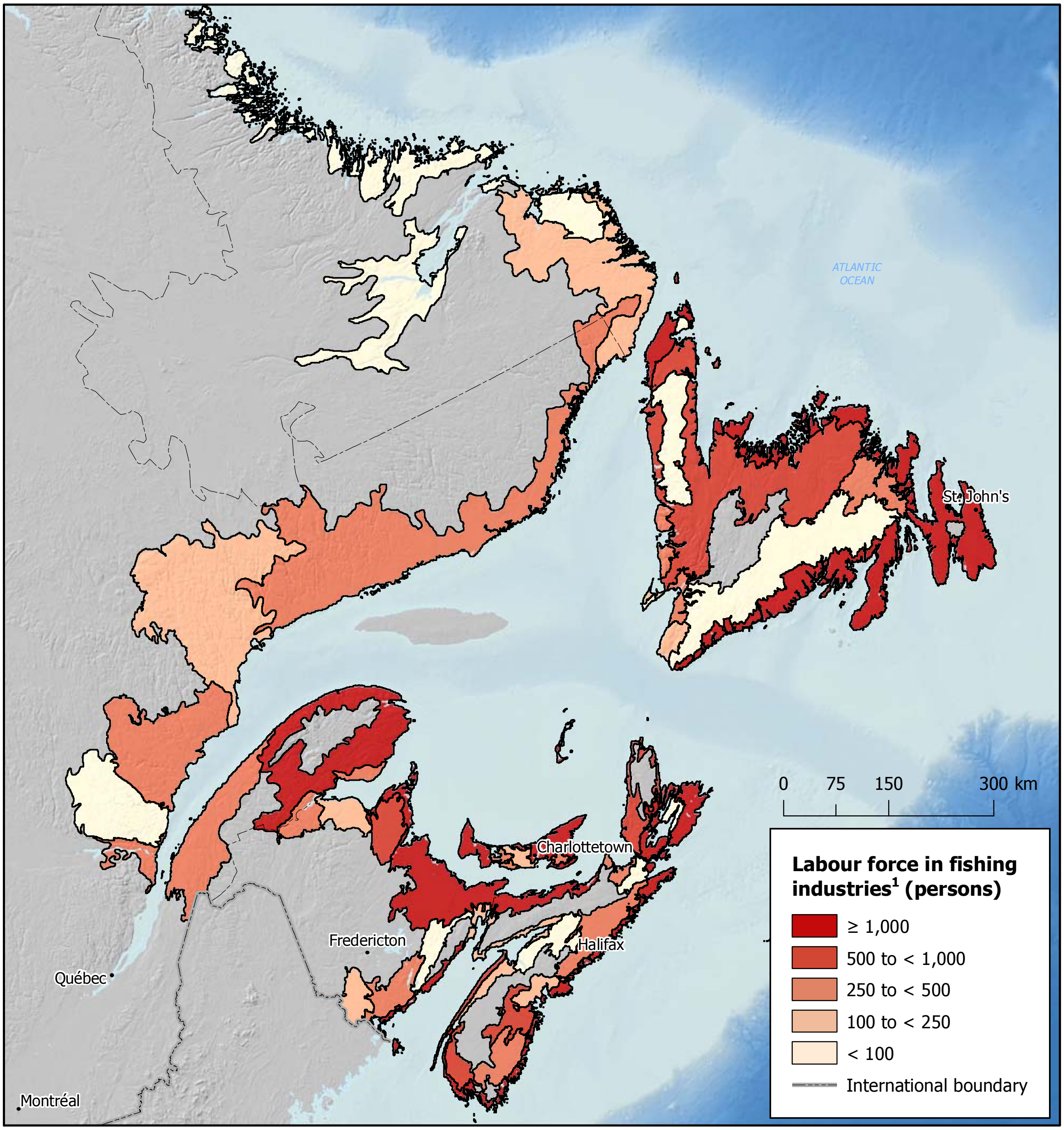
Map 3.12
Marine coastal fisheries ecumene, West coast, 2006



1. Fishing industries include: the Fishing industry (NAICS 1141), the Seafood Product Preparation and Packaging industry (NAICS 3117) and the Aquaculture industry (NAICS 1125).

Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 2006 Census of Population.

Map 3.13
Marine coastal fisheries ecumene, East coast, 2006



1. Fishing industries include: the Fishing industry (NAICS 1141), the Seafood Product Preparation and Packaging industry (NAICS 3117) and the Aquaculture industry (NAICS 1125).

Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 2006 Census of Population.

Table 3.7
Labour force in fishing industries for selected marine coastal ecodistricts, 2006

	Ecodistrict	Labour force		
		Total [1]	Fishing industries [2]	Share of total
	code	persons		percent
Canada	...	**736,525**	**74,740**	**10.1**
Atlantic Drainage Area	...	**475,475**	**64,750**	**13.6**
Atlantic	516	54,535	9,165	16.8
Northumberland Shore	500	43,050	7,355	17.1
North Shore	470	22,050	5,175	23.5
Northeastern Barrens	471	31,005	4,975	16.0
South Coast Barrens	474	20,995	3,640	17.3
Charlottetown	536	16,350	2,935	18.0
Gaspe Peninsula	478	21,435	2,650	12.4
Southeastern Barrens	475	33,720	2,420	7.2
O'Leary	534	8,500	2,030	23.9
Madelaine	539	9,085	1,875	20.6
Pacific Drainage Area	...	**261,050**	**9,990**	**3.8**
Fraser Lowland	959	165,360	4,000	2.4
Nanaimo Lowland	956	55,230	2,095	3.8
Hecate Lowland	946	8,695	1,355	15.6
Nahwitti Lowland	952	4,380	490	11.2
Leeward Island Mountains	955	6,050	475	7.9
Georgia Lowland	958	5,525	390	7.1
Windward Island Mountains	954	3,605	370	10.3
Strait of Georgia	957	5,460	325	6.0
Queen Charlotte	943	1,040	190	18.3
Queen Charlotte Strait	947	680	95	14.0

1. Total labour force refers to the labour force in census blocks where the fishing industry is present, not the total labour force present in the ecodistrict.
2. Fishing industries include: the Fishing industry (NAICS 1141), the Seafood Product Preparation and Packaging industry (NAICS 3117) and the Aquaculture industry (1125).

Note(s): Ecodistricts are characterized by distinctive assemblages of relief, fauna, water bodies, soils, landforms and geology and are the lowest level in the Ecological Framework of Canada hierarchy (Appendix H). Coastal ecodistricts are ecodistricts that have a marine shoreline and in which part of the population is active in the marine fishing industry.

Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 2006 Census of Population.

3.6 Freshwater wetland ecosystem goods and services

As water moves through the environment it is transformed and transferred from one state to another and from one ecosystem to the next. Wetlands, areas where water accumulates for prolonged periods of time, play an important role in this cycling of water.

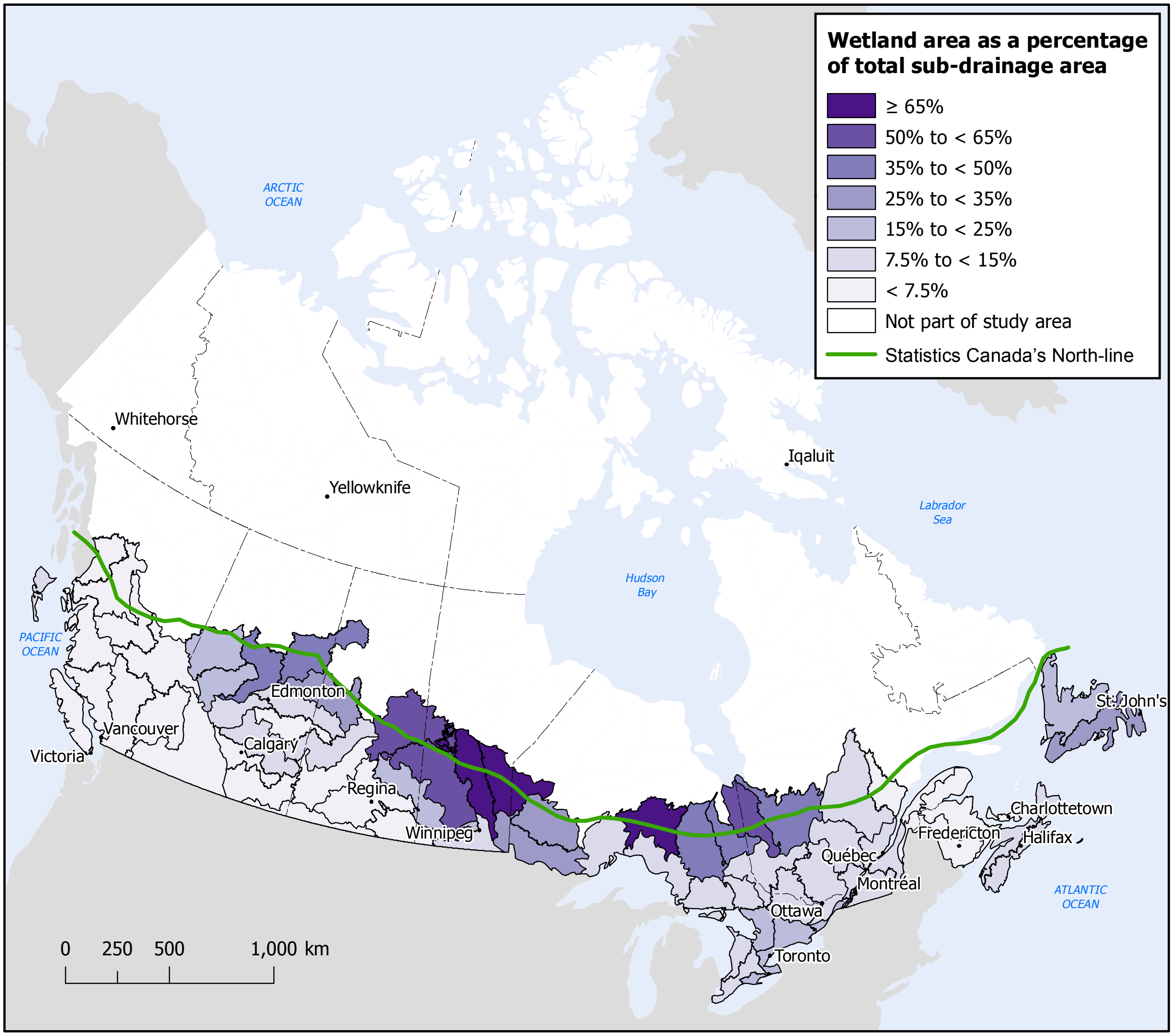
Wetlands are defined as lands that are seasonally or permanently covered by shallow water, including lands where the water table is at or close to the surface. Wetlands can be classed into two main categories—organic and mineral—and are further subdivided into five classes: marshes, swamps, bogs, fens, and shallow open waters.

As the interface between the aquatic and terrestrial environments, wetlands provide critical functions and EGS at global, regional and local scales. Some important functions and services provided by wetlands include the regulation of water flow and quality, soil retention and formation, and climate. Wetlands also provide habitat for many living organisms—plant and animal, terrestrial and aquatic—and provide opportunities for recreation and education.

3.6.1 Freshwater wetland extent in Canada

Wetlands exist in a diverse range of environments and natural settings across Canada (Map 3.14). Although there are many types of wetlands, two are of particular interest nationally and regionally because of their extent and number—*peatlands* and prairie *pothole wetlands*.

Map 3.14
Distribution of freshwater wetlands, southern Canada, by sub-drainage area



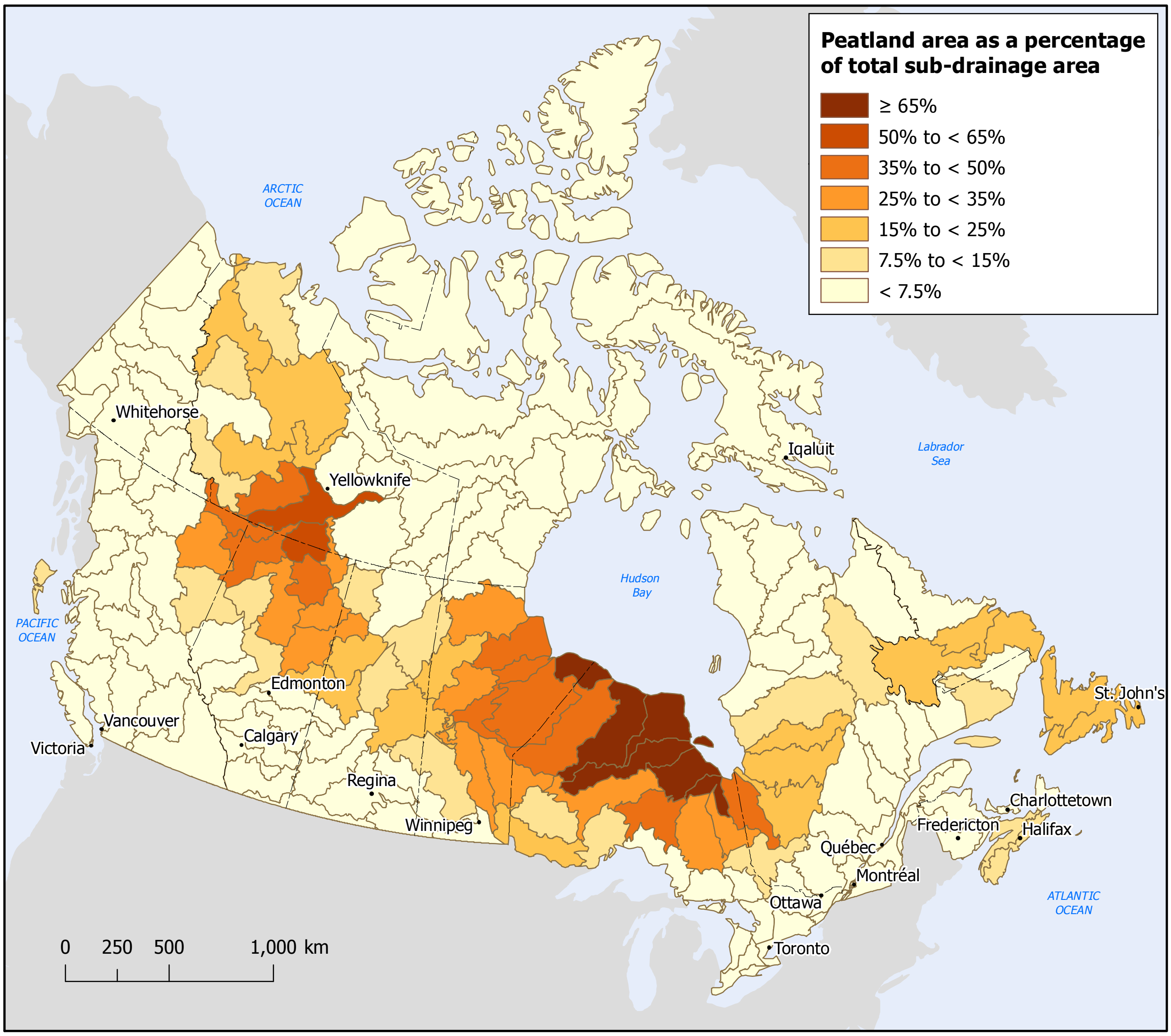
Note(s): Wetland estimates were calculated using coefficients derived from high resolution wetland datasets from the provinces of Prince Edward Island, Nova Scotia, New Brunswick, Ontario, Quebec and Alberta and Environment Canada. Agriculture and Agri-Food Canada's 30 m land cover product was also used as a base layer reference. Wetland datasets represented full or partial coverage of the provinces.

Source(s): Prince Edward Island Department of Environment, Energy and Forestry, 2009, 2009 *PEI Wetland Inventory*, www.gov.pe.ca/gis/index.php3?number=1036522&lang=E (accessed December 2012). Nova Scotia Department of Natural Resources, 2013, *Forest Inventory – Geographic Information Systems*, http://novascotia.ca/natr/forestry/gis/dl_forestry.asp (accessed March 2013). New Brunswick Department of Environment and Local Government, 2013, *Regulated Wetlands*, www.snb.ca/geonb1/e/DC/RW.asp (accessed October 2011). Ontario Ministry of Natural Resources, Science and Information Branch, 2008, *Southern Ontario Land Resource Information System (SOLRIS)*. Alberta Environment and Sustainable Resource Development, 2011, *Alberta CWCS High – Resolution Wetland Inventory*, https://maps.srd.alberta.ca/geoportal/catalog/search/resource/details.page?amp;uuid=%7B7A280790-2D88-4486-9D6A-B8CC2F6FEF1E%7D (accessed March 2013). Environment Canada, 2012, *National Wetland Database*, Canadian Wildlife Service, Ottawa, Ontario. Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/ (accessed October 9, 2012).

Peatlands are organic wetlands and are the most common type of wetland in Canada, covering approximately 12% of the landscape[40] and accounting for about 76% of total wetland area.[41] Large areas of peatland are concentrated in the Hudson Bay Lowlands, northern Alberta, central Northwest Territories and parts of Manitoba (Map 3.15). More than a third (37%) of the total extent of peatland is frozen year-round and is particularly sensitive to climate change.[42]

40. Tarnocai, C., 2009, "The impact of climate change on Canadian Peatlands," *Canadian Water Resources Journal*, Vol. 34, no. 4, pages 453 to 466.
41. Federal, Provincial and Territorial Governments, 2010, *Canadian Biodiversity: Ecosystem Status and Trends 2010*, Canadian Councils of Resource Ministers, *www.biodivcanada.ca/ecosystems* (accessed May 29, 2013). Please note that the total extent and proportion of wetland area may be underestimated due to data availability.
42. Tarnocai, C., 2009.

Map 3.15
Distribution of peatland, by sub-drainage area



Source(s): Tarnocai, C., I.M. Kettles and B. Lacelle, 2011, *Peatlands of Canada*, Geological Survey of Canada, Open File 6561 (digital database), CD-ROM. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

The prairie pothole region—an area covering approximately 390,000 km² or 22% of the Prairie provinces[43]—is known for the hundreds of thousands of small 'pothole' wetlands that dot the landscape. These small depression wetlands are usually less than 1 hectare (ha) in size, can have water present on a continuous or sporadic basis and can be connected to or isolated from surface waters in streams and rivers.[44] Although individually small, collectively these wetlands represent a major component of the hydrology of the Prairies.

Over the years, development and other pressures have resulted in all types of wetlands being converted to other land uses in and around agricultural and settled areas, resulting in important losses in wetland EGS. It is estimated that since 1800, 200,000 km² of Canadian wetlands have been lost, due to drainage and other types of human activity.[45]

In the Prairies, small pothole wetlands have experienced continuous land use pressure, with losses occurring at a higher rate than other types of wetlands, usually to agricultural land use.[46] Since 1900 between 40% and 70% of the potholes in the western Prairies of North America have been drained, mainly to increase agricultural production.[47,48,49]

In southern Ontario, the area covered by large wetlands—those greater than 10 ha in size—decreased by approximately 72% from pre-settlement times to 2002.[50] Although the majority of this change occurred long ago, there was a 3.5% reduction from 1982 to 2002.[51]

In Alberta it is estimated that up to 64% of wetlands have been lost from early settlement to 1996.[52] The government of Alberta has found that wetland area has decreased by 24% in the Shepard Slough, just east of Calgary, a loss of 7.7 km² between 1962 and 2005.[53]

The impact of climate change on wetlands is coming into increased focus due to changes in the water cycle including changes in the frequency, magnitude, timing and distribution of precipitation and increased temperatures particularly in arctic and subarctic regions. Researchers have found that approximately 60% of Canada's peatland will likely be impacted by climate change, resulting in significant changes to their ecosystem services. Changes are already occurring and are expected to accelerate, resulting in degradation of permafrost in the subarctic and boreal regions and severe drying of peatlands in the southern portions of the boreal region.[54]

3.6.2 Towards valuation of wetland goods and services

Recent studies in Ontario found that wetland ecosystems provide the highest value of services and are the most valuable ecosystems on a per hectare basis.[55] The value of EGS from Great Lakes coastal wetlands in southern Ontario is estimated at close to $15,000/ha/year.[56] In the Credit Valley watershed of southern Ontario, wetland services were estimated to have an annual benefit of $187 million/year.[57] Potential wetland values for recreation in the Shepard Slough region of Calgary were estimated

43. National Wetlands Working Group, 1988, "Wetlands of Canada," *Ecological Land Classification Series*, No. 24, Sustainable Development Branch, Environment Canada, Ottawa Ontario and Polyscience Publications Inc., Montreal Quebec.
44. Westbrook, C.J., N. Bruner, I. Phillips and J.-M. Davies, 2011, *Wetland Drainage Effects on Prairie Water Quality: Final Report*, Centre for Hydrology Report No. 9, Centre for Hydrology, University of Saskatchewan, Saskatoon.
45. Government of Canada, 1991, *The Federal Policy on Wetland Conservation*, Catalogue no. CW66-116/1991E.
46. Bartzen, B.A., K.W. Dufour, R.G. Clark and F.D. Caswell, 2010, "Trends in agricultural impact and recovery of wetlands in prairie Canada," *Ecological Applications,* Vol. 20, no. 2, pages 525 to 538.
47. Brinson, M.M. and A.I. Malvárez, 2002, "Temperate freshwater wetlands: types, status, and threats," *Environmental Conservation*, Vol. 29, no. 2, pages 115 to 133.
48. Euliss Jr., N.H., R.A. Gleason, A. Olness, R.L. McDougal, H.R. Murkin, R.D. Robarts, R.A. Bourbonniere and B.G. Warner, 2006, *North American Prairie Wetlands are Important Nonforested Land-Based Carbon Storage Sites*, USGS Northern Prairie Wildlife Research Center, Paper 23, *http://digitalcommons.unl.edu/usgsnpwrc/23* (accessed September 16, 2013).
49. Watmough, M.D. and M.J. Schmoll, 2007, *Environment Canada's Prairie and Northern Region habitat monitoring program Phase II: recent habitat trends in the Prairie Habitat Joint Venture*, Technical Report Series No. 493, Environment Canada, Canadian Wildlife Service, Edmonton Alberta.
50. Ducks Unlimited Canada, 2010, *Southern Ontario Wetland Conversion Analysis*, Final Report.
51. Ducks Unlimited Canada, 2010.
52. Lockey, D.A., 2011, *Wetlands, Land Use and Policy: Alberta's Keystone Ecosystem at a Crossroads*, Green Paper presented at the Annual Conference of the Alberta Institute of Agrologists, Banff, Alberta, March 16, 2011.
53. Alberta Environment and Water, 2012, *Ecosystem Services Approach Pilot on Wetlands*: *Integrated Assessment Report*, *http://environment.gov.ab.ca/info/posting.asp?assetid=8493&searchtype=asset&txtsearch=ecosystem services* (accessed September 24, 2013).
54. Tarnocai, C., 2009, "The impact of climate change on Canadian Peatlands," *Canadian Water Resources Journal*, Vol. 34, no. 4, pages 453 to 466.
55. Monetary and functional valuations of wetland services in this section have not been validated by Statistics Canada. The numbers are included as examples of service values derived by other researchers. Please refer to noted papers and documents for information on methodologies used.
56. Troy, A. and K. Bagstad, 2009, *Estimating Ecosystem Services in Southern Ontario*, Ontario Ministry of Natural Resources.
57. Kennedy, M. and J. Wilson, 2009, *Estimating the Value of Natural Capital in the Credit River Watershed*, Drayton Valley, Alberta, Pembina Institute.

at approximately $4.4 million/year.[58] The annual value of phosphorus and nitrogen processing by wetlands in British Columbia's Lower Fraser Valley was estimated to be between $452/ha and $1,270/ha.[59]

Although some organizations have determined monetary values for wetland EGS, from an accounting perspective, valuation remains a challenge due to difficulties in determining appropriate methods and a lack of data. To begin, the inventory of Canada's wetlands remains incomplete, largely as a result of the size of the country and the number of wetlands, but also because of the complexity in delineating these areas.

As a result, this analysis focuses on contextual characteristics of the regional supply and demand for wetland goods and services as a way to understand the relative importance and value of specific wetland EGS in different areas of the country.[60] Contextual analysis allows for important aspects of value to be explored and better understood, particularly where monetary or physical measures are not feasible.

Tables 1, 2, and 3 (Appendix F) present supply characteristics and indicators of demand for wetland services by sub-drainage area (SDA) focusing on population density, agricultural land use, livestock density, land modification,[61] fertilizer application, and nitrogen and phosphorous from manure and comparing these indicators of demand to the extent or supply of wetlands in each area. For example, the Lake Ontario and Niagara Peninsula-02H, Central St. Lawrence-02O and Northern Lake Erie-02G SDAs have among the highest population and livestock densities and proportions of land in agriculture. These indicators help represent the pressure that humans put on ecosystems and can also indicate a higher demand for the services provided by wetlands.

The section also focuses in more detail on wetland EGS for a single drainage region—the Assiniboine-Red in the Prairies—as an example of how local and regional studies can determine the benefits of wetland EGS.

58. Alberta Environment and Water, 2012, *Ecosystem Services Approach Pilot on Wetlands*: *Integrated Assessment Report*, *http://environment.gov.ab.ca/info/posting.asp?assetid=8493&searchtype=asset&txtsearch=ecosystem services* (accessed September 24, 2013).
59. Olewiler, N.D., 2004, *The value of natural capital in settled areas of Canada*, Ducks Unlimited Canada and the Nature Conservancy of Canada.
60. This assessment focused solely on SDAs located in the southern portion of the country.
61. A higher level of landscape modification is indicated by smaller natural land parcel sizes and larger distances to natural land parcels.

3.6.2.1 Streamflow regulating services

Wetlands modify the flow of water as it passes through *watersheds*,[62] lessening the magnitude of peak flows[63] and supplementing low flows. This flow regulation service is valuable in watersheds with a high variability of *streamflow*, peak flows that can result in damaging floods or low flows that exacerbate drought. In Canada, variability of flow,[64] flood hazards and drought conditions are most acute on the Prairies, although similar concerns exist on a more localized scale elsewhere. The floods in Calgary and High River in 2013 bring attention to the issue of streamflow variability, highlighting the importance of the benefits provided by wetlands.

The hydrology of Canada's prairie region is highly variable, with fairly well-drained, semi-arid basins in the southwest part and many wetlands and lakes in the relatively wet north-central and eastern parts.[65] The Missouri-11A, Souris-05N and Western Lake Winnepeg-05S SDAs in the southern Prairies, had the highest water flow variability in the country (Table 3, Appendix F). This variability in water flow is one of a number of factors, which, if taken together, would favour higher values for particular wetlands.

Total water storage capacity lost due to wetland drainage in Calgary's Shepard Slough region is estimated at 9.2 million m^3 between 1965 and 2011.[66] This represents a 20% decrease in available water storage capacity—which would have an impact on the provision of flood protection services.

3.6.2.2 Water quality regulating services

Wetlands have the ability to trap and retain nutrients and pollutants that are dissolved or suspended in water, helping to purify or clean water. Information on phosphorous and nitrogen in livestock manure, fertilizer application, population and agricultural

62. Watersheds are areas draining naturally to a water course or other given point.
63. Millennium Ecosystem Assessment, 2005, *Ecosystems and Human Well-Being: Wetlands and Water Synthesis*, World Resources Institute, Washington DC.
64. Flow variability is represented by the coefficient of variation calculated using monthly streamflow values from Environment Canada's Water Survey of Canada, for the years 1990 to 2010 for rivers with the highest streamflow in the sub-drainage area.
65. Fang, X., A. Minke, J. Pomeroy, T. Brown, C. Westbrook, X. Guo and S. Guangul, 2007, A *Review of Canadian Prairie Hydrology: Principles, Modelling and Response to Land Use and Drainage Change*, Centre for Hydrology Report No. 2, Version 2, Centre for Hydrology, University of Saskatchewan, Saskatoon.
66. Alberta Government, 2011, "Ecosystem Services Approach Pilot on Wetlands," *Economic Valuation Technical Report*.

production provide context to explain the demand for and value of water quality regulating services offered by wetlands (Table 3, Appendix F).

Eutrophication—the nutrient enrichment of water bodies—is an important issue across Canada and is particularly important in areas that have been highly modified by human activities, for example in the Prairies, southern Ontario and southeastern Quebec. The Northern Lake Erie-02G SDA in southern Ontario had among the highest levels of land modification, represented by natural land parcel size, as well as some of the highest proportions of fertilized land area and amounts of nitrogen and phosphorous coming from manure (Table 3, Appendix F).

3.6.2.3 Soil retention and formation services

Soil retention and formation in wetlands occurs where eroded soil and suspended soil particles settle out of the water as they enter wetlands, rather than being transported away by streams or rivers. This soil retention process is particularly important in highly modified areas of the Prairies, the south shore of the St. Lawrence in Quebec, and southern Ontario, because erosion is more likely to occur where there is modification of the landscape.

Higher *total suspended solids* and turbidity[67] levels can be an indication that there is more erosion taking place. In 2011, turbidity levels of untreated surface waters supplying drinking water plants were highest in the Prairies and the St. Lawrence drainage regions.[68]

3.6.2.4 Habitat provision services

Wetlands provide diverse habitat for terrestrial and aquatic organisms, for example nesting habitat for birds. Approximately 600 species of wildlife, including more than one-third of Canada's species at risk, are found in wetlands.[69] Given their high biological productivity, wetland habitat services have a high value in all places but are particularly valuable in areas where wetlands are relatively scarce or where the landscape is highly modified, such as southern Ontario and the Prairies (Tables 1 and 3, Appendix F). Ranking SDAs by natural land parcel size indicates that the Prairies have eight of the top ten most modified landscapes while the remaining two SDAs are in southern Ontario (Table 3, Appendix F).

3.6.2.5 Climate regulating services

Carbon sequestration is an important global service provided by wetlands. Peatlands for example, help mitigate the release of greenhouse gases such as methane into the atmosphere by storing carbon as organic matter in the ground. With permafrost melt occurring as a result of climate change, these peatlands may begin to emit greenhouse gases instead of storing carbon, reversing some of the climate regulating services that they are currently providing.[70]

Significant amounts of peatlands are present in the SDAs surrounding the Hudson Bay Lowlands, northern Alberta, central Manitoba, the Northwest Territories and parts of Newfoundland and Nova Scotia (Table 1, Appendix F). Within the Hudson and James Bay Lowlands, a region along the south and west of Hudson and James Bay, peatlands cover a continuous area of approximately 290,000 km^2 to 325,000 km^2.[71,72,73,74]

3.6.2.6 Recreation and education services

SDAs along the Windsor to Québec City corridor and across the southern Prairies have been highly modified from their natural state. Agriculture area accounts for over 74% of the land area in 12 of these SDAs, while six SDAs have among the highest proportions of settled area in the country (Table 3, Appendix F). As well, the number and size of wetlands has decreased over

67. Turbidity is the cloudiness of a liquid caused by suspended particles and is used as a measure of water quality.
68. Statistics Canada, 2013, *Survey of Drinking Water Plants, 2011*, Catalogue no. 16-403-X.
69. Ducks Unlimited Canada, 2006, "Wetlands," *Natural Values: Linking the Environment to the Economy*, *www.ducks.ca/assets/2012/06/nv6_wet.pdf* (accessed July 17, 2013).
70. Tarnocai, C., 2009, "The impact of climate change on Canadian Peatlands," *Canadian Water Resources Journal*, Vol. 34, no. 4, pages 453 to 466.
71. O'Reilly, B.C. and S.A. Finkelstein, 2011, *Carbon accumulation and vegetation dynamics in the Hudson Bay Lowlands: allogenic or autogenic forcings?*, presented at GeoHydro2011, joint meeting of the Canadian Quaternary Association (CANQUA) and the Canadian Chapter of the International Association of Hydrogeologists (IAH-CNC), August 28 to 31, 2011, in Québec City, Quebec, *www.geohydro2011.ca/gh2011_user/cle_usb/pdf/doc-2365.pdf* (accessed September 16, 2013).
72. Worthy, D.E.J., I. Levin, F. Hopper, M.K. Ernst and N.B.A. Trivett, 2000, "Evidence for a link between climate and northern wetland methane emissions," *Journal of Geophysical Research: Atmospheres*, Vol. 105, Issue D3, pages 4031 to 4038.
73. Roulet, N.T., A. Jano, C.A. Kelly, L.F. Klinger, T.R. Moore, R. Protz, J.A. Ritter and W.R. Rouse, 1994, "Role of the Hudson Bay lowland as a source of atmospheric methane," *Journal of Geophysical Research: Atmospheres*, Vol. 99, Issue D1, pages 1439 to 1454.
74. Tarnocai, C., 2000, "Carbon pools in soils of the Arctic, Subarctic and Boreal regions of Canada," pages 91 to 103 in Lal, R., J.M. Kimble and B.A. Stewart (eds.), 2000, *Global Climate Change and Cold Regions Ecosystems*, Advances in Soil Science, Boca Raton Fla., Lewis Publishers.

time.[75,76] The predominance of modified landscapes, combined with decreases in the number and size of wetlands, affects the availability of nature-based educational and recreational opportunities.

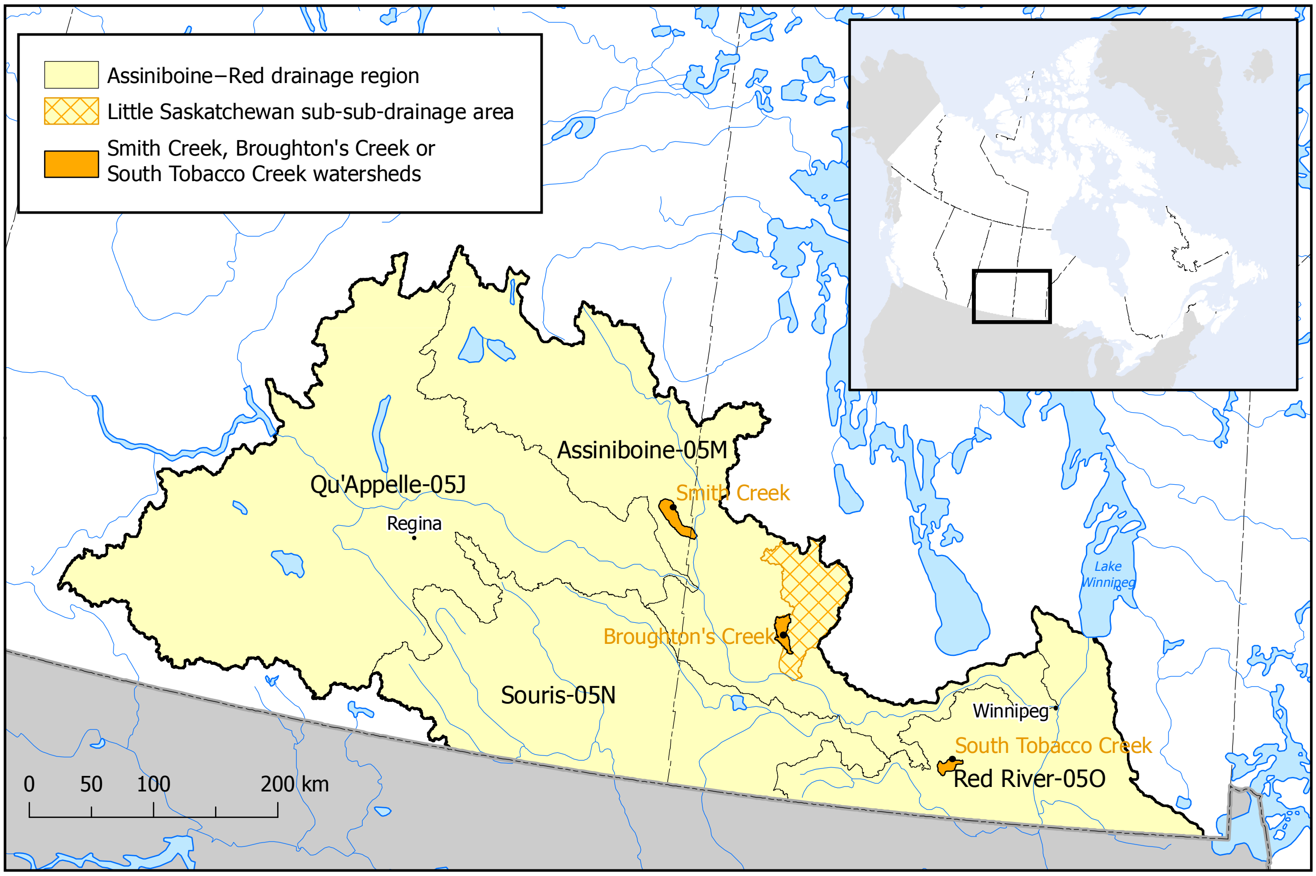
Remaining wetlands, such as those of Point Pelee National Park and Rondeau Provincial Park located in the relatively densely populated Northern Lake Erie–02G SDA in southern Ontario, take on added value due to the scarcity of wetlands and natural landscapes in neighbouring areas. Both parks and their surrounding communities benefit from the economic activity of people travelling to and using the parks for recreational and educational services such as bird watching and hiking.

75. Federal, Provincial and Territorial Governments, 2010, *Canadian Biodiversity: Ecosystem Status and Trends 2010*, Canadian Councils of Resource Ministers, *www.biodivcanada.ca/ecosystems* (accessed May 29, 2013).
76. Ducks Unlimited Canada, 2010, *Southern Ontario Wetland Conversion Analysis*, Final Report.
77. Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011.

3.6.3 Focus area: Assiniboine-Red drainage region

The Assiniboine-Red drainage region is located in the south central and southeastern portion of the Prairies (Map 3.16). The landscape of the Assiniboine-Red drainage region has been highly modified by agricultural activities. In 2011, it supported a population of 1.47 million people (Table 2, Appendix F) and over 34,400 farms.[77] The drainage region includes the Assiniboine-05M, Souris-05N, Qu'Appelle-05J and the Canadian part of the Red River-05O SDAs, all of which drain into Lake Winnipeg. These four SDAs are among the most modified landscapes in Canada with over 75% of the landscape used for agriculture. Parcel sizes of natural landscapes are among the smallest in Canada, while the distances to natural landscapes are among the largest in the country. To put this in perspective, a person in the Qu'Appelle would have to walk 1.3 km on average before finding a natural land area greater than 250 m^2.

Map 3.16
Assiniboine-Red drainage region



Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Wetlands cover between 10% and 20% of the Assiniboine-Red landscape (Table 1, Appendix F), although the region also includes many small pothole wetlands that are not easily measured and are therefore largely excluded from the estimate.[78] In this region many wetlands have been and continue to be lost through drainage and conversion to agricultural land. For example, between 1968 and 2005, 21% of wetland area in the Broughton's Creek watershed in Manitoba was degraded or lost due to drainage activities.[79]

78. Small wetlands measuring less than 1 ha have been excluded from this analysis since the capacity to detect and measure small wetlands on a regional basis is quite limited.
79. Yang, W., X. Wang, S. Gabor, L. Boychuk and P. Badiou, 2008, *Water Quantity and Quality Benefits from Wetland Conservation and Restoration in the Broughton's Creek Watershed*, Ducks Unlimited Canada publication.
80. Statistics Canada, 2010, "Freshwater supply and demand in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X.

Various regional and local studies have demonstrated that wetlands in the Assiniboine-Red drainage region provide various EGS including streamflow and water quality regulation, soil retention and formation and habitat provision. Findings from these studies are detailed below.

3.6.3.1 Streamflow regulating services

The Assiniboine-Red drainage region had the highest variability in water yield—an estimate of renewable freshwater—in Canada for the period from 1971 to 2004.[80] The Missouri, Souris River, Battle and Qu'Appelle SDAs have high variability of streamflow and experience recurrent flooding (Table 3, Appendix F). Extreme flows, both high and low, are important concerns, and the region has had several large floods including the 1995 and 2011 floods on the

Assiniboine River and the 1997 and 2007 floods on the Red River.

Between 1968 and 2005, the total number of wetlands in the Broughton's Creek watershed in the Little Saskatchewan sub-sub-drainage area decreased by 70% as a result of drainage and degradation, resulting in an 18% increase in peak flows following rainfall and a 30% increase in streamflow.[81]

3.6.3.2 Water quality regulating services

Water quality is a major concern in the Assiniboine-Red drainage region due to the level of nutrients such as phosphorous and nitrogen.[82] SDAs in the southern part of the Prairies, including those draining from the United States, contribute to the quantity of nutrients entering Lake Winnipeg. For example, SDAs in this drainage region have some of the largest percentages of land area where fertilizer is applied compared to other areas of the country (Table 3, Appendix F). Because the extent of wetland area is relatively low in these SDAs compared to many other parts of the country, the value of these scarce wetlands and the demand for their water quality regulating services should be relatively high.

3.6.3.3 Soil retention and formation services

In 2011, the highest turbidity readings in Canada for surface waters supplying drinking water plants were found in the Prairies, including the Assiniboine-Red drainage region.[83] While high turbidity readings may not be representative of all water bodies in the Assiniboine-Red drainage region, the data emphasize the value of and demand for water quality regulating services provided by wetlands.

3.6.3.4 Habitat provision services

There is high demand for habitat provision services in the Assiniboine-Red drainage region as there are extensive agricultural areas and fragmented natural landscapes. While prairie potholes represent only 10% of the continent's waterfowl breeding area, they produce half of North America's waterfowl in an average year.[84] A study of small wetlands in the Tobacco Creek watershed has shown that restoration can be an efficient and cost effective means for establishing habitat, particularly for waterfowl and water quality improvements.[85]

Comparing the supply or extent of wetlands to the many demands for their services can help demonstrate the value of wetland EGS. In the case of the Assiniboine-Red drainage region, the many demands for wetland EGS relative to the low supply of wetlands illustrates how the value of wetland EGS in this drainage region could be considered among the highest in Canada.

81. Ducks Unlimited Canada, 2008, *The Impacts of Wetland Loss in Manitoba*, *www.gov.mb.ca/waterstewardship/iwmp/willow_creek/documentation/ducks.pdf* (accessed September 11, 2013).
82. Environment Canada and Manitoba Water Stewardship, 2011, *State of Lake Winnipeg: 1999 to 2007*, *www.manitoba.ca/waterstewardship/water_quality/state_lk_winnipeg_report/pdf/state_of_lake_winnipeg_rpt_technical_low_resolution.pdf* (accessed July 22, 2013).
83. Statistics Canada, 2013, *Survey of Drinking Water Plants, 2011*, Catalogue no. 16-403-X.
84. Batt, B.D.J., M.G. Anderson, C.D. Anderson and F.D. Caswell, 1989, "The use of prairie potholes by North American ducks," pages 204 to 227 in van der Valk, A.G. (ed.), 1989, *Northern prairie wetlands*, Iowa State University Press, Ames.
85. Yang, W., Y. Liu, P.C. Boxall, K. Packman, M. Weber and S. Gabor, 2009, *Integration of Watershed Planning and the Agricultural Policy Framework for the Provision of Ecological Goods and Services: A Pilot Watershed Approach for Wetland Restoration and Retention*, pages 13 to 29 in Proceedings of the Ecological Goods and Services Technical Meeting, Ottawa, Canada, Prairie Habitat Joint Venture (Edmonton).

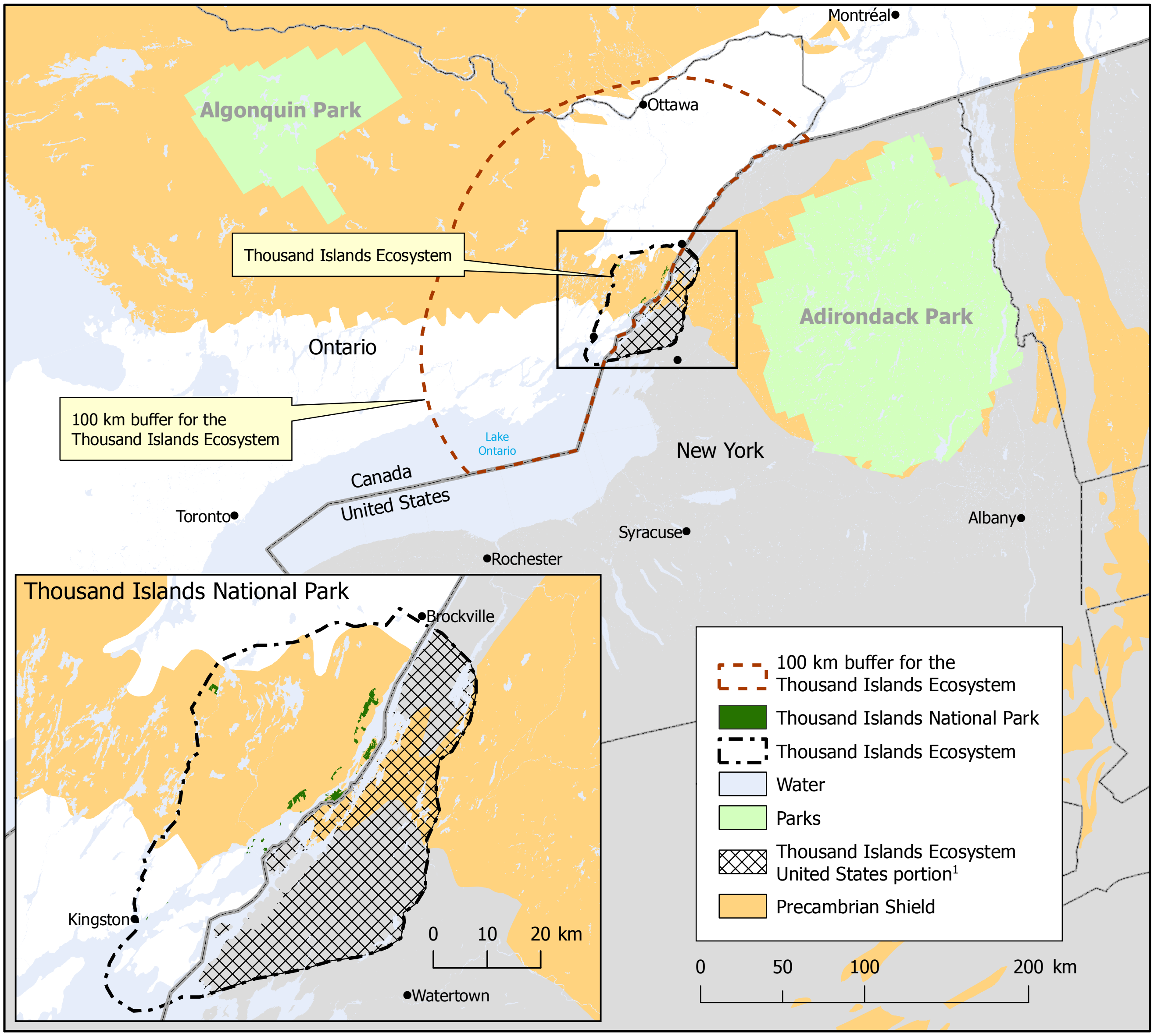
Section 4

Thousand Islands National Park case study

The Thousand Islands National Park, located within the larger Thousand Islands Ecosystem in Eastern Ontario (Map 4.1), was selected as a case study for valuing ecosystem goods and services (EGS). The case study brings together some of the concepts presented in previous sections, showing how ecosystem accounting can be used. The park, established in 1904, is one of the smallest national parks in Canada at 22.3 km^2,[1] and faces many pressures affecting the state of its environment.[2]

1. The study area includes all lands scheduled under the *National Parks Act* and recently acquired federal crown lands with the exception of some smaller islets, and the Main Duck and Yorkshire Islands in Lake Ontario.
2. Canadian Heritage (Parks Canada), 1998, *State of the Parks: 1997 Report,* Catalogue no. R64-184/1997E.

Map 4.1
Thousand Islands National Park and Ecosystem



1. United States portion of the Thousand Islands Ecosystem is not part of the study area.

Source(s): Parks Canada, 2013, *Thousand Islands National Park GIS polygons*, Thousand Islands National Park of Canada, Ontario. Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Garrity, C.P. and D.R. Soller, 2009, *Database of the Geologic Map of North America—Adapted from the map by J.C. Reed, Jr. and others (2005)*, U.S. Geological Survey Data Series 424, http://pubs.usgs.gov/ds/424/ (accessed July 10, 2013).

Protected areas help prevent degradation of ecosystems and EGS, and can also increase the value of EGS provided by these sites.[3] The Thousand Islands National Park, like all parks in Canada, provides many benefits and is highly valued by Canadians.[4,5]

For the case study, pressures on the landscape were identified, land cover for the national park and surrounding ecosystem were analysed, and two methods to estimate monetary values for ecosystem service flows from the national park were applied. For more information about the case study area, methodology and limitations, see Appendix G.

The Thousand Islands National Park was created primarily as a place for recreation, including picnicking, camping and boating.[6] Since the 1980s, awareness has grown that the Thousand Islands area represents a unique and important Canada-U.S. transboundary ecosystem and attention has been directed towards environmental protection. The ecosystem is situated on an extension of the Canadian Shield, at the centre of an important wildlife habitat area ranging from Algonquin Park in Ontario to Adirondack Park in New York State (known as the 'A2A' region) and provides habitat for more than 30 species at risk due to loss of habitat because of human activity and natural changes.

Some of the major threats to the park's ecological integrity include pressures associated with visitors in the park, habitat fragmentation and loss, introduction of exotic species and pollution.[7] Although 10 km^2 of ecologically significant land were added in 2005, the park itself is relatively small and fragmented and does not fully represent the ecosystem of the greater Thousand Islands area to which it belongs.

Parks Canada is working to integrate two objectives: providing recreational opportunities for Canadians while preserving and protecting the fragile resources of the park.[8] However, protecting the park's ecological integrity must be pursued on a scale larger than the park itself since environmental stressors come both from within and outside the park boundaries.[9,10] Community engagement is important since the majority of property in the area is privately owned and managed.[11] The Aboriginal community and Parks Canada have participated in joint work related to the protection of the National Park.

4.1 Pressures on the Thousand Islands National Park

The Thousand Islands National Park is influenced by human activity that occurs within the park and by development pressures from population growth, agriculture and other activities that have impacts on the surrounding landscape (Maps 4.2 to 4.8). Protected areas, which help buffer communities from environmental risks,[12] covered 564 km^2 (1.7%) of the landscape within 100 km of the Thousand Islands Ecosystem in 2012.[13,14]

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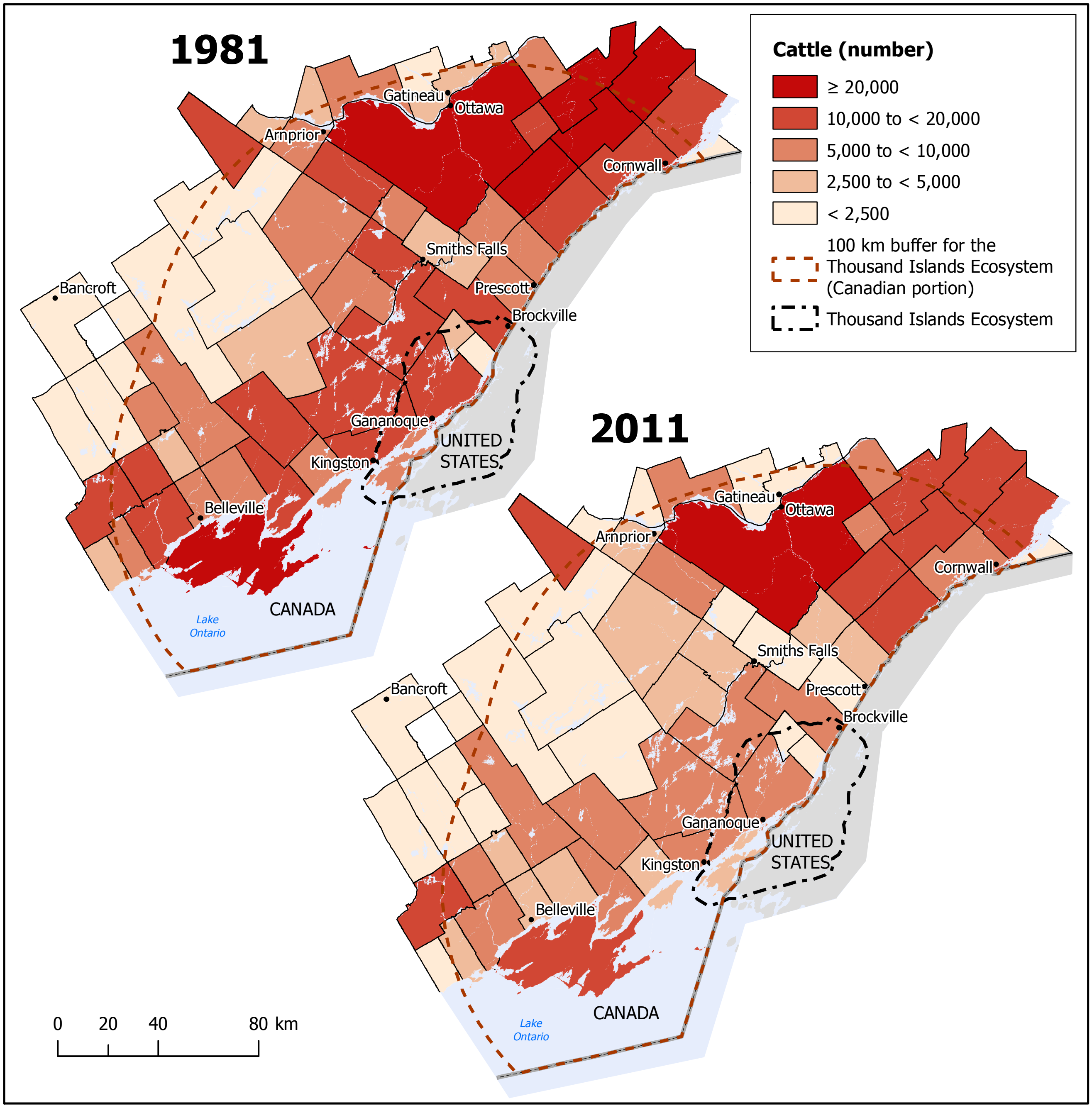
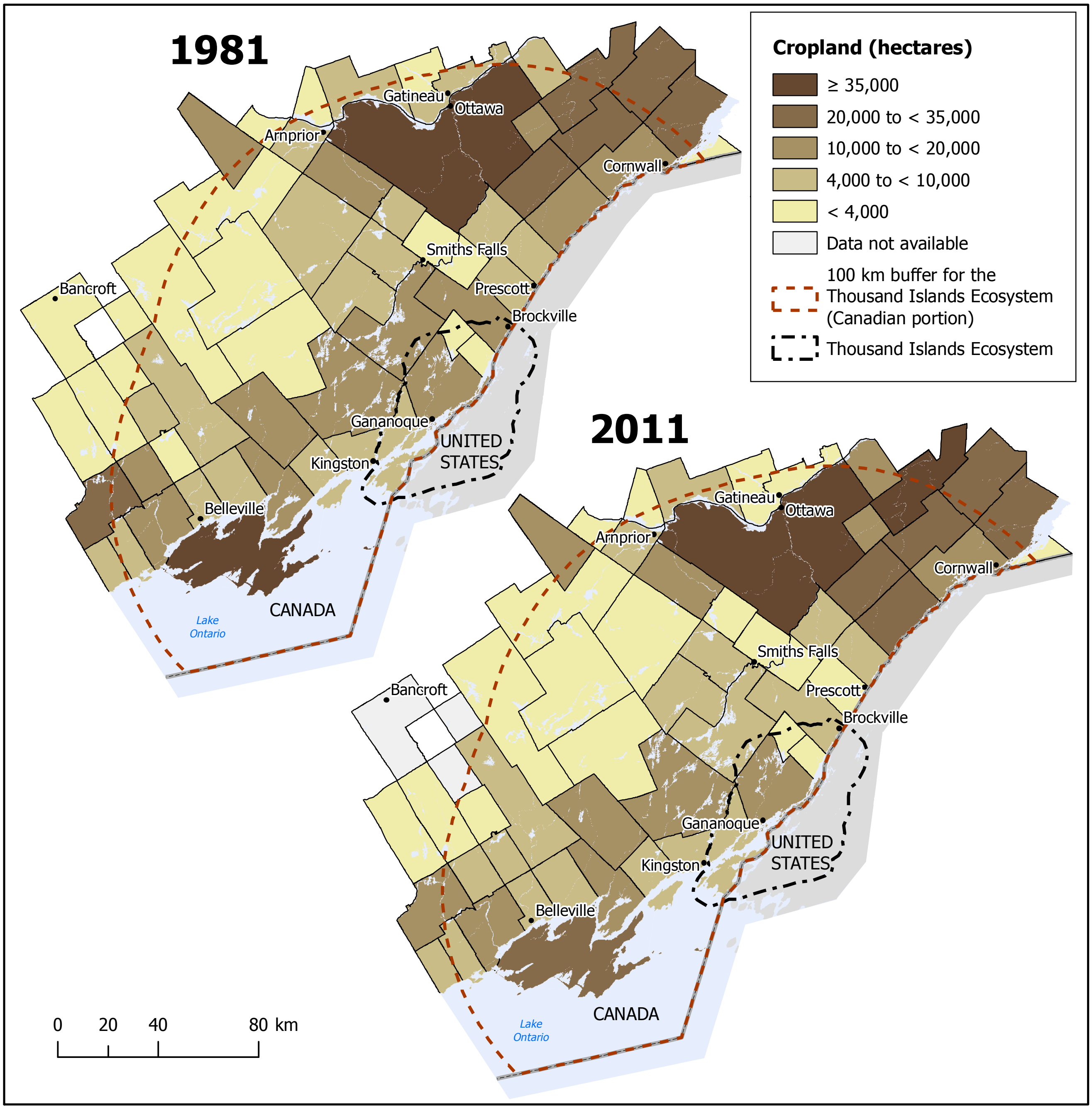
3. Kettunen, M., N. Dudley, A. Bruner, L. Pabon, N. Conner, A. Berghöfer, A. Vakrou, K.J. Mulongoy, J. Ervin, S.B. Gidda, M. Bouamrane, P. ten Brink, S. Chape, P. Morling, A. Seidl and S. Stolton, 2009, "Chapter 8: Recognising the value of protected areas," *The Economics of Ecosystems and Biodiversity for National and International Policy Makers*.
4. The Outspan Group Inc., 2011, *Economic Impact of Parks Canada*, prepared for Parks Canada.
5. Parks Canada, 2013, *Parks Canada Agency Report on Plans and Priorities 2013-14*, Catalogue no. R61-70/2013E-PDF.
6. Parks Canada, 2013, *Thousand Islands National Park of Canada: A Big Anniversary for a Small Park*, *www.pc.gc.ca/eng/pn-np/on/lawren/natcul/natcul1/d.aspx* (accessed July 18, 2013).
7. Parks Canada, 2013, *Thousand Islands National Park of Canada: Ecological Integrity Statement*, *www.pc.gc.ca/eng/pn-np/on/lawren/natcul/natcul2.aspx* (accessed July 25, 2013).
8. Parks Canada, 2013, *Thousand Islands National Park of Canada*: *A Big Anniversary for a Small Park*, *www.pc.gc.ca/eng/pn-np/on/lawren/natcul/natcul1/d.aspx* (accessed September 10, 2013).
9. Parks Canada, 2010, *St. Lawrence Islands National Park of Canada: Management Plan*, Catalogue no. R64-105/78-2009E. Note: The park name was changed in 2013 to Thousand Islands National Park.
10. Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*.
11. Parks Canada, 2013, "Engaging Communities Through Outreach," *Thousand Islands National Park of Canada*, *www.pc.gc.ca/eng/pn-np/on/lawren/plan/plan2/b.aspx* (accessed September 3, 2013).
12. Kettunen, M., N. Dudley, A. Bruner, L. Pabon, N. Conner, A. Berghöfer, A. Vakrou, K.J. Mulongoy, J. Ervin, S.B. Gidda, M. Bouamrane, P. ten Brink, S. Chape, P. Morling, A. Seidl and S. Stolton, 2009, "Chapter 8: Recognising the value of protected areas," *The Economics of Ecosystems and Biodiversity for National and International Policy Makers*.
13. Canadian Council on Ecological Areas, 2012, *CARTS Reports*, *www.ccea.org/en_cartsreports.html* (accessed February 2012). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.
14. Includes protected areas administered federally and provincially, as well as indigenous or privately held conservation lands that are recognized by protected area jurisdictions as being part of their network.

Map 4.2
Pressure on the Thousand Islands National Park: Cattle, 1981 and 2011



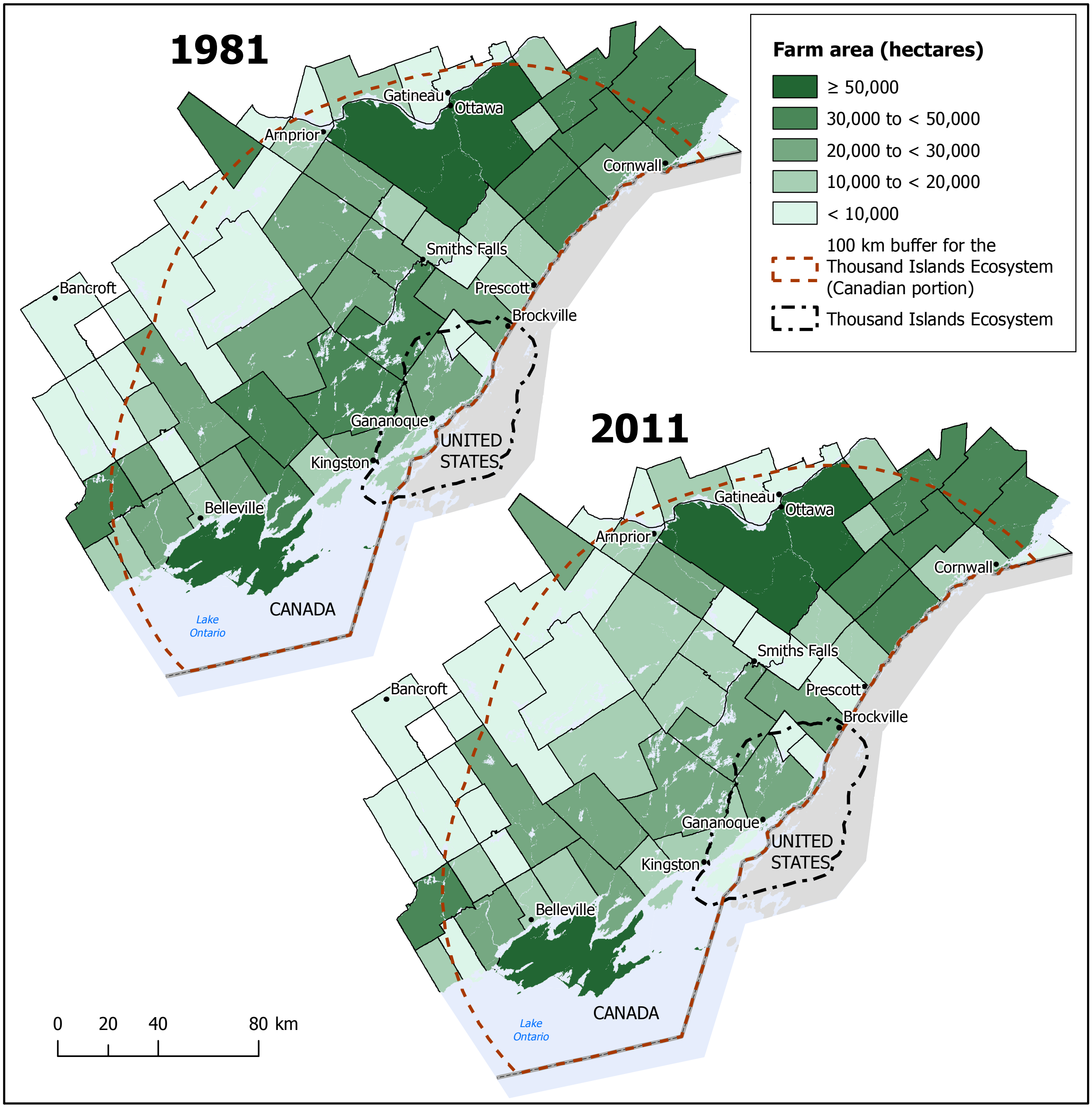
Source(s): Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Statistics Canada, 2011, *Boundary Files*, Catalogue no. 92-160-X. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Agriculture.

Map 4.3
Pressure on the Thousand Islands National Park: Cropland, 1981 and 2011



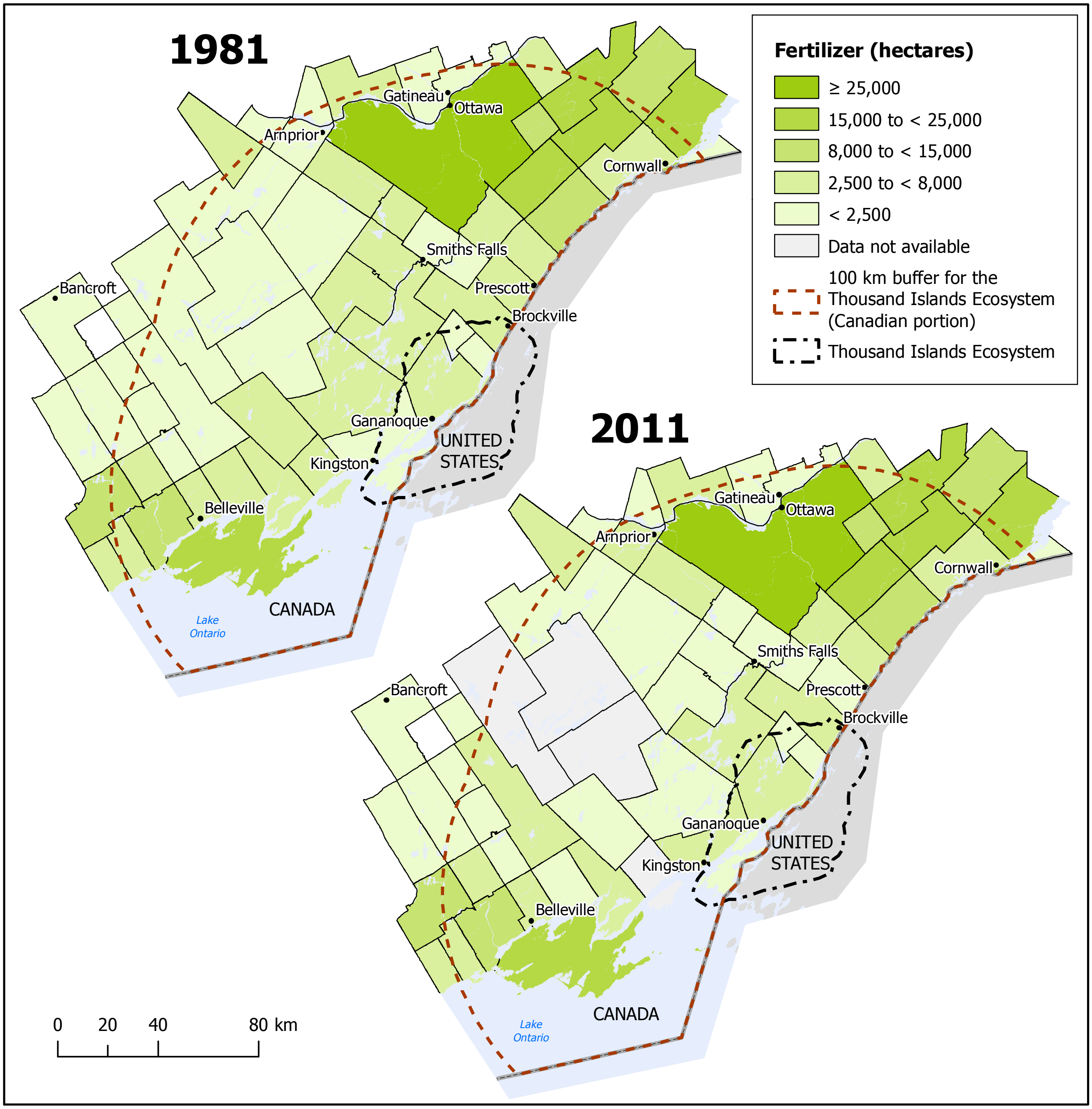
Source(s): Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Statistics Canada, 2011, *Boundary Files*, Catalogue no. 92-160-X. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Agriculture.

Map 4.4
Pressure on the Thousand Islands National Park: Farm area, 1981 and 2011



Source(s): Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Statistics Canada, 2011, *Boundary Files*, Catalogue no. 92-160-X. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Agriculture.

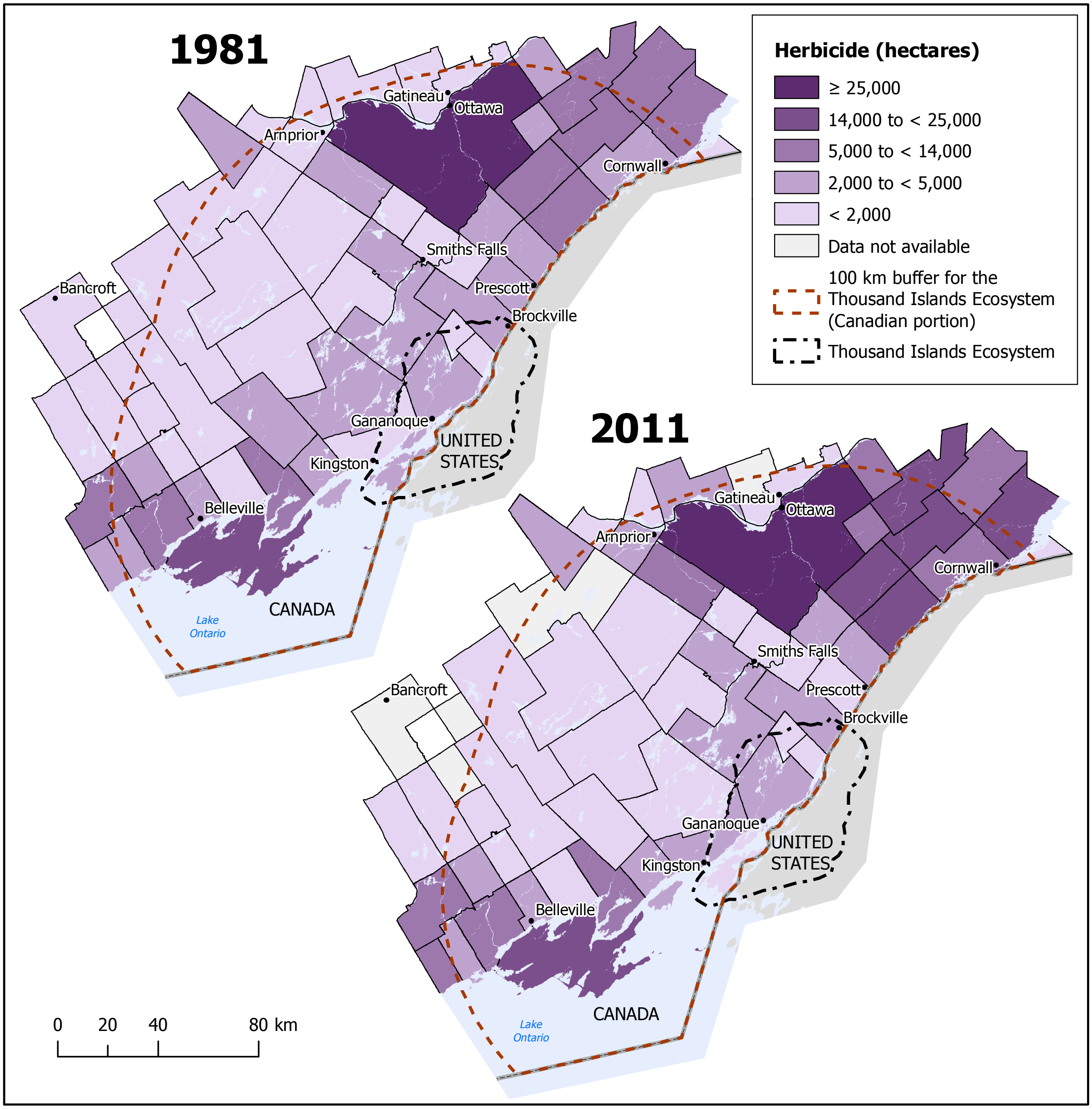
Map 4.5
Pressure on the Thousand Islands National Park: Area fertilized, 1981 and 2011



Note(s): The data are reported for the year preceding the census year.

Source(s): Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Statistics Canada, 2011, *Boundary Files*, Catalogue no. 92-160-X. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Agriculture.

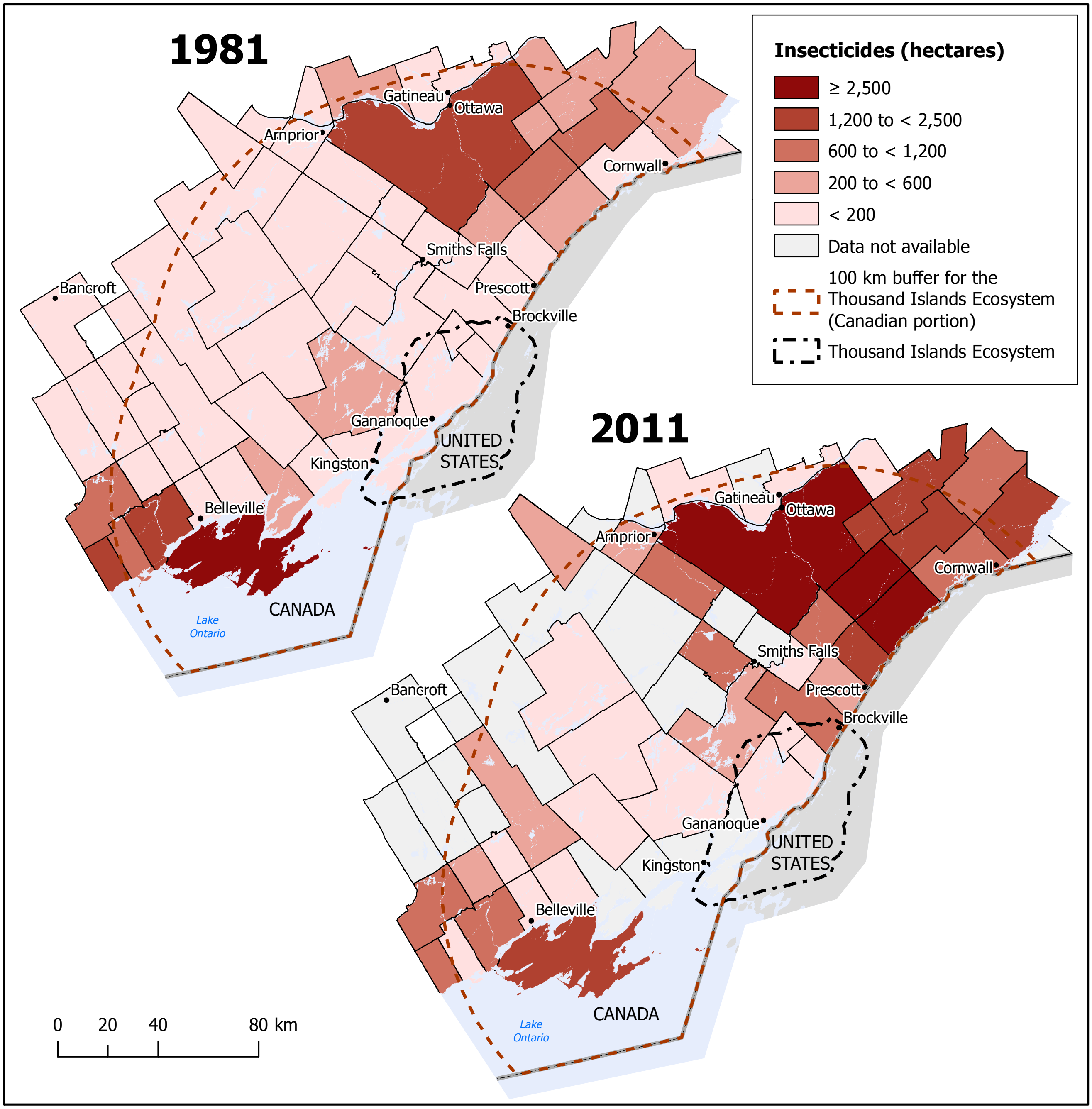
Map 4.6
Pressure on the Thousand Islands National Park: Area treated with herbicide, 1981 and 2011



Note(s): The data are reported for the year preceding the census year.

Source(s): Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Statistics Canada, 2011, *Boundary Files*, Catalogue no. 92-160-X. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Agriculture.

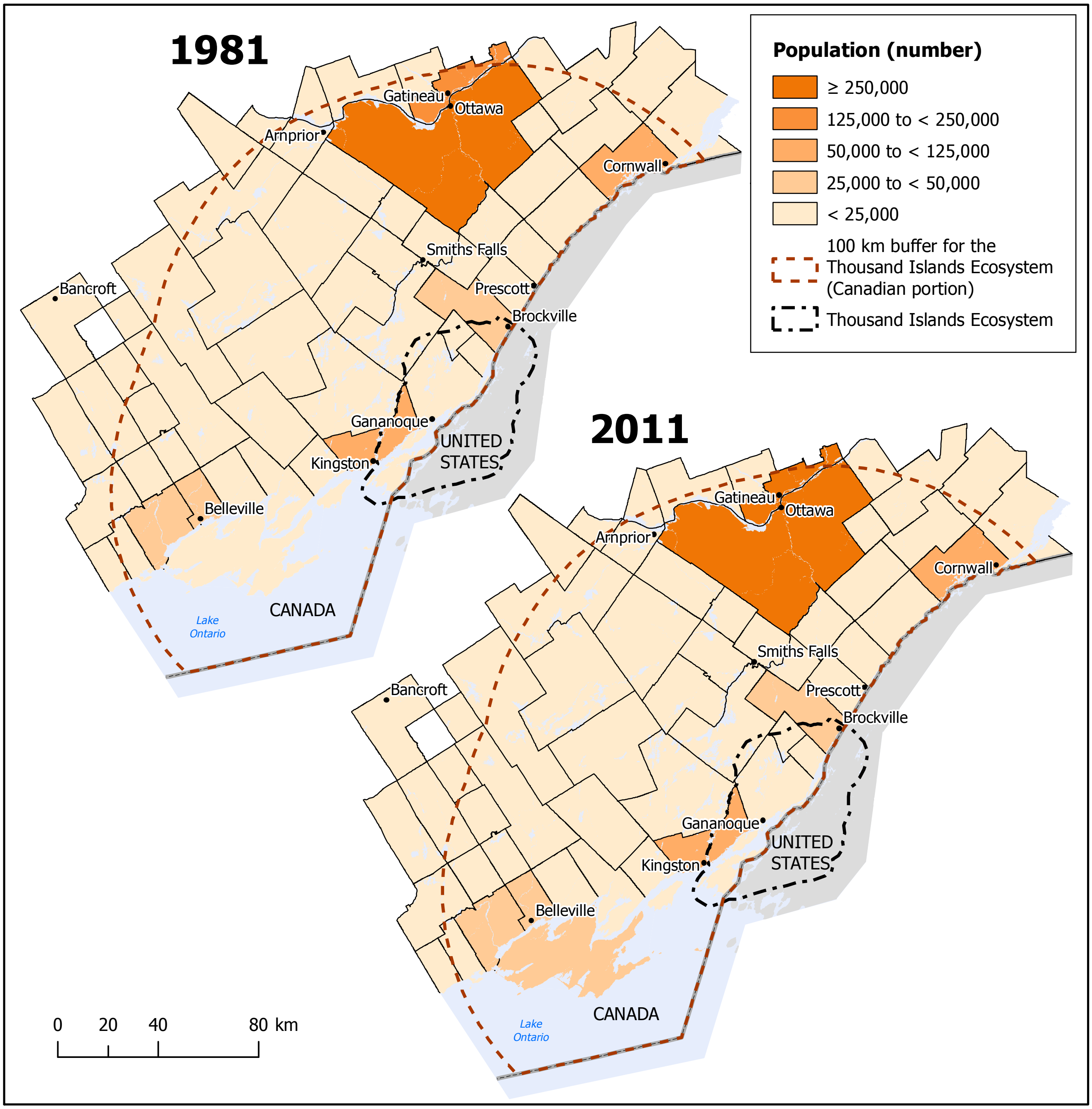
Map 4.7
Pressure on the Thousand Islands National Park: Area treated with insecticide, 1981 and 2011



Note(s): The data are reported for the year preceding the census year.

Source(s): Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Statistics Canada, 2011, *Boundary Files*, Catalogue no. 92-160-X. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Agriculture.

Map 4.8
Pressure on the Thousand Islands National Park: Population, 1981 and 2011



Source(s): Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*. Statistics Canada, 2011, *Boundary Files*, Catalogue no. 92-160-X. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Agriculture.

In 2011, close to two million people lived within 100 km of the Thousand Islands Ecosystem,[15] a 47% increase from 1981 (Table 4.1). The population density was 59 persons/km^2 in 2011, compared to 49 persons/km^2 for the Thousand Islands Ecosystem itself. The population density was 272 persons/km^2 in the nearby Lake Ontario and Niagara Peninsula-02H sub-drainage area (SDA) and 148 persons/km^2 in the Central St. Lawrence-02O SDA (Table 1, Appendix C).

15. Census of Population and Census of Agriculture data in this section are presented for all census consolidated subdivisions within the Thousand Islands Ecosystem 100 km buffer area and Thousand Islands Ecosystem boundaries.

Table 4.1
Population and agriculture, Thousand Islands Ecosystem 100 km buffer area and Thousand Islands Ecosystem, 1981 and 2011

	Thousand Islands Ecosystem 100 km buffer area			Thousand Islands Ecosystem		
	1981	2011	percent change	1981	2011	percent change
Population						
Population (number)	1,303,008	1,914,906	47.0	156,678	206,038	31.5
Population density (people/km^2) [1]	40.3	59.3	47.0	37.4	49.2	31.5
Agriculture						
Farms (number)	15,026	9,119	-39.3	1,915	1,205	-37.1
Area of farmland (hectares)	1,313,657	1,013,851	-22.8	186,178	133,825	-28.1
Area of cropland (hectares)	606,017	599,400	-1.1	69,837	62,471	-10.5
Cattle (number)	608,329	320,064	-47.4	79,995	42,451	-46.9
Area treated with herbicide (hectares) [2]	199,475	318,405	59.6	15,119	18,429	21.9
Area treated with insecticide (hectares) [2]	17,186	35,629	107.3	634	1,362	114.8
Area fertilized (hectares) [2]	306,582	314,956	2.7	23,947	16,662	-30.4

1. The total area for the Thousand Islands Ecosystem 100 km buffer area is 32,306 km^2 and the total area for the Thousand Islands Ecosystem is 4,189 km^2.
2. The data are reported for the year preceding the census year.

Note(s): Totals (number or hectares) presented in this table sum the values for census consolidated subdivisions (CCS) within the 100 km buffer zone established for the Thousand Islands Ecosystem or the Thousand Islands Ecosystem boundary. These sums may be underestimates since some CCS data were confidential or were too unreliable to be published, and are as such treated as zeros. The United States portion of the Thousand Islands Ecosystem and the 100 km buffer zone is outside the scope of this analysis.

Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation of data from the 1981 and 2011 Censuses of Population and Censuses of Agriculture.

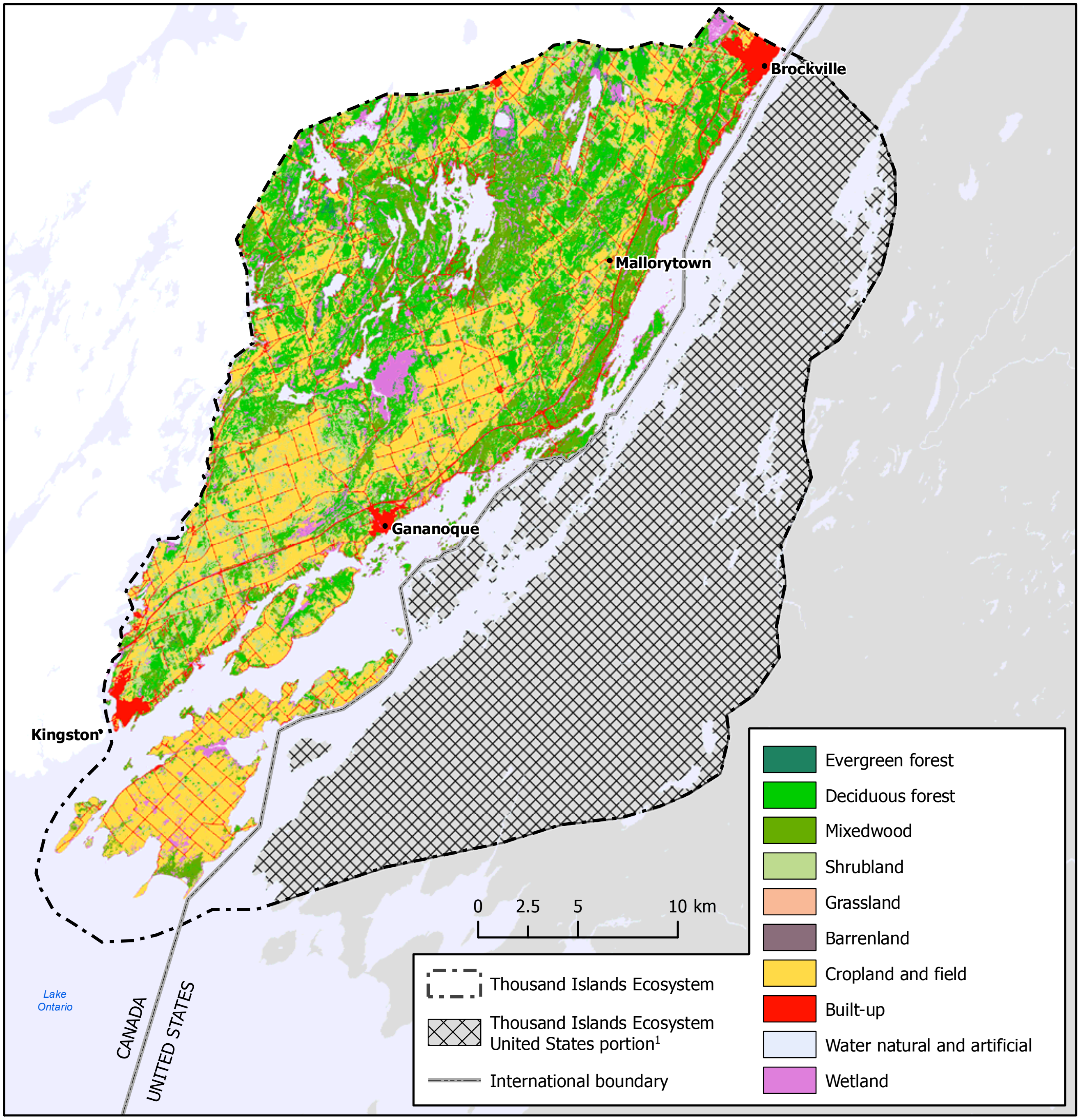
In 2011, the Thousand Islands Ecosystem buffer area, most of which drains towards the St. Lawrence River, supported over 9,100 farms. However, the number of farms and the area of farmland decreased by 39% and 23% respectively, from 1981 to 2011. Similar trends occurred in the Thousand Islands Ecosystem, where the number of farms decreased by 37% and farm area decreased by 28%.

The number of cattle also decreased from 1981 to 2011 in both the Thousand Islands Ecosystem and the buffer area (-47%). Cropland remained relatively stable in the buffer area (-1%), but decreased 11% in the Thousand Islands Ecosystem. Other farm activity measures, including area sprayed with herbicides and insecticides increased in both areas, while area fertilized remained stable in the buffer area but decreased 30% in the Thousand Islands Ecosystem.

4.2 Land cover of the Thousand Islands Ecosystem

To help estimate the value of EGS provided by the Thousand Islands National Park, land cover assets were analyzed through the use of satellite imagery (Map 4.9, Chart 4.1). Land cover for both the National Park and the Thousand Islands Ecosystem were compared (Table 4.2).

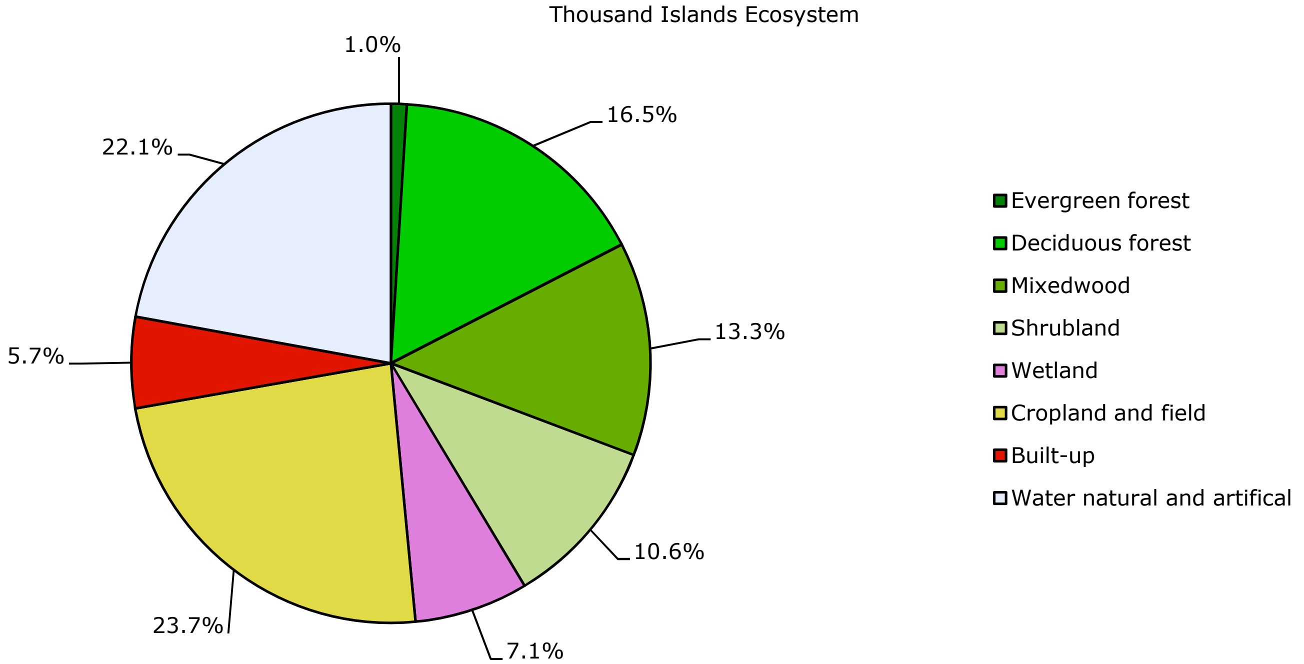
Map 4.9
Land cover, Thousand Islands Ecosystem, 2007

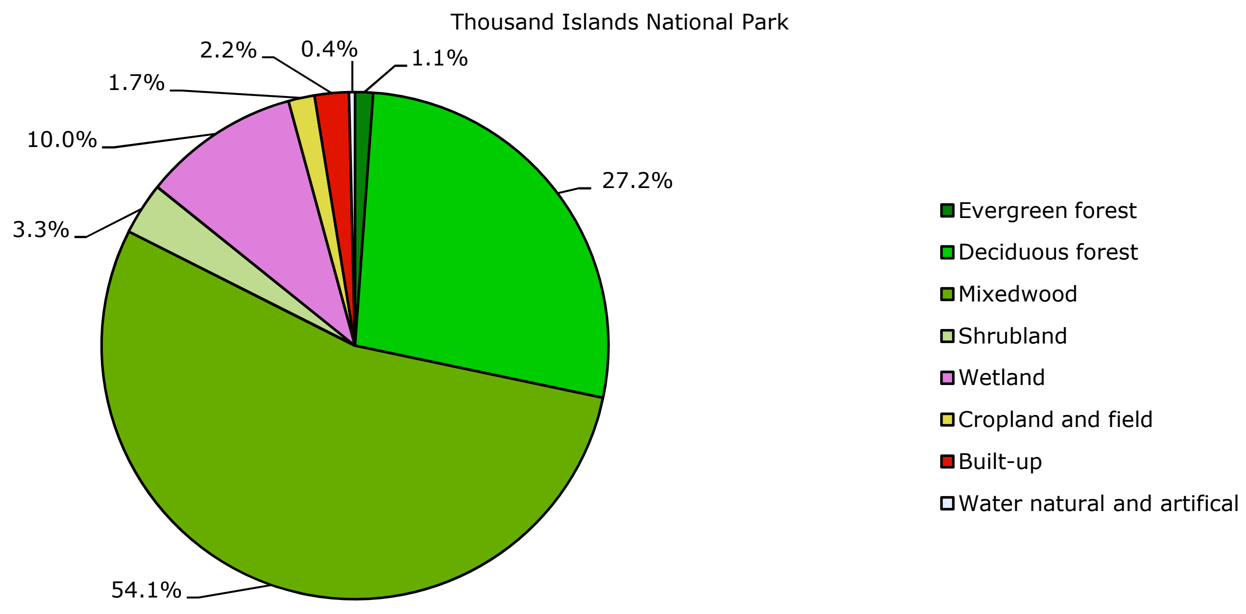


1. United States portion of the Thousand Islands Ecosystem is not part of the study area.

Source(s): Parks Canada, Natural Resource Conservation, 2012, special tabulation, Land Cover Map of the Greater Thousand Islands National Park Ecosystem using Landsat Thematic Mapper and Random Forest Models, LANDSAT 5. Francis, M. and J. Leggo, 2004, *State of the Park Report 2004: St. Lawrence Islands National Park of Canada*. ESRI, 2013, *Tele Atlas North America*.

Chart 4.1
Land cover, Thousand Islands Ecosystem and National Park, 2007





Note: For the Thousand Islands Ecosystem, grassland and barrenland round down to 0% and are not represented in this chart.

Source: Parks Canada, Natural Resource Conservation, 2012, special tabulation, Land Cover Map of the Greater Thousand Islands National Park Ecosystem using Landsat Thematic Mapper and Random Forest Models, LANDSAT 5.

Table 4.2
Land cover, Thousand Islands Ecosystem and National Park, 2007

	Thousand Islands Ecosystem		Thousand Islands National Park	
	hectares	percent	hectares	percent
Total	**182,174**	**100.0**	**2,229**	**100.0**
Evergreen forest	1,773	1.0	25	1.1
Deciduous forest	29,991	16.5	605	27.2
Mixedwood	24,242	13.3	1,207	54.1
Shrubland	19,380	10.6	74	3.3
Grassland	10	0 s	0	0.0
Barrenland	2	0 s	0	0.0
Wetland	12,939	7.1	223	10.0
Cropland and field	43,219	23.7	37	1.7
Built-up	10,313	5.7	49	2.2
Water natural and artificial	40,306	22.1	8	0.4

Source(s): Parks Canada, Natural Resource Conservation, 2012, special tabulation, Land Cover Map of the Greater Thousand Islands National Park Ecosystem using Landsat Thematic Mapper and Random Forest Models, LANDSAT 5.

Forest (31%), cropland and field (24%) and water (22%) were the most prevalent land covers for the Thousand Islands Ecosystem; wetlands and built-up areas covered 7% and 6% of the area respectively. The Thousand Islands National Park has a larger proportion of its area in forest (82%) and wetland (10%) and lower proportion in cropland and field (2%) and built-up areas (2%) compared to the larger ecosystem area.

4.3 Monetary valuation of ecosystem goods and services in Thousand Islands National Park

Estimating monetary values for the EGS provided by the Thousand Islands National Park can be useful for a variety of reasons, such as providing information about conservation and restoration needs, supporting policy and decision-making and raising public awareness about the contributions this protected area makes to human well-being. The case study was also initiated to evaluate the impact of data quality on the production of monetary values, which would feed into an ecosystem account structure as proposed by the System of Environmental-Economic Accounting (SEEA): Experimental Ecosystem Accounting. Two examples illustrate how monetary values can be estimated for the ecosystem services of the park area.

In the first example, the overall value of several ecosystem services provided by the park is estimated using existing monetary values of EGS taken from a report for southern Ontario.[16] The second example estimates monetary values of a few selected ecosystem services by land cover type, making use of published valuation studies and applying (transferring) monetary values found to similar areas within the Thousand Islands National Park in a process called benefit transfer. These experimental estimates show how this type of approach can be used to assess monetary values for EGS in a case study context. See Textbox 3 for more information on benefit transfer

16. The spatial coverage of this report, Troy, A. and K. Bagstad, 2009, *Estimating Ecosystem Services in Southern Ontario,* Ontario Ministry of Natural Resources, includes the Thousand Islands National Park area.

Textbox 3: Benefit transfer valuation methods

Estimating EGS values can be very time consuming and costly to carry out, which is why methods have been devised to transfer existing valuation work from previously studied sites to new areas, known as policy sites. This technique is generally referred to as 'benefit transfer' or 'value transfer.'

There are two main approaches to benefit transfer:

- 'Unit value transfer' transfers a monetary value from a study site to a new site (e.g., $ per hectare or $ per beneficiary). Unit values are often adjusted to reflect biophysical or socio-economic differences between the two sites.

- 'Function value transfer' is a more complex method that uses regression methods to relate the value of EGS with biophysical and socio-economic characteristics from a study site to estimate the value of EGS for a second site with known biophysical and socio-economic characteristics. This approach can be based on results from a single study or a number of studies. For example, in the case of meta-analysis transfer, data is consolidated from a large number of studies.

Studies show that both methods are subject to uncertainty and various errors. For example, tests have shown that unit value transfer errors are often in the range of ±40% or more.[17]However, errors can be reduced by ensuring study and policy sites share similar characteristics.[18,19]

valuation and Appendix G for more information about the case study methodologies.

4.3.1 Valuation of ecosystem goods and services by land cover type

The Thousand Islands National Park area provides a wide variety of services to people in and around the park. For example, wetland areas help to filter sediments and sustain water flows for plants, animals and human populations. Forests provide habitats for wildlife and supply opportunities for recreation, tourism and human well-being.

These EGS provide a wide range of benefits that can be estimated through monetary valuation. This assessment applies monetary values of EGS flows per hectare of land taken from an existing report for southern Ontario[20] and aggregates the value of these EGS by land cover type.[21] The assessment covers the following EGS: atmospheric regulation; water quality, nutrient and waste regulation; water supply regulation; soil retention and erosion control; habitat and biodiversity; pollination and dispersal services; disturbance avoidance; recreation; aesthetic and amenity; and other cultural services.[22]

Using this experimental approach, estimates of the annual value of EGS for the Thousand Islands National Park were produced, ranging from $12.5 million to $14.7 million for 2012, depending on the satellite data resolution and classification accuracy (Table 4.3). Of the available land cover compilations that would also permit future analysis of parks in other areas of the country, Parks Canada LANDSAT-TM provided the finest resolution land cover information, one that was better suited to this regional study. Using this data source, forests and wetlands provided the highest contributions to the EGS values estimated for this site at 70% and 28% respectively. However, using the Troy and Bagstad source data, 50% of the value of EGS is attributed to forest cover, 45% to wetland and 5% to water. These values represent an estimate of the flows of EGS from the Thousand Islands National Park for the year and do not represent the total value of the national park or its land area.

17. Navrud, S. and R.C. Ready (eds.), 2007, *Environmental Value Transfer: Issues and Methods,* Springer, Dordrecht, The Netherlands.
18. Brander, L., A. Ghermandi, O. Kuik, A. Markandya, P.A.L.D. Nunes, M. Schaafsma and A. Wagtendonk, 2010, "Scaling up Ecosystem Services Values: Methodology, Applicability and a Case Study," *Fondazione Eni Enrico Mattei Working Paper Series*, Issue 9.
19. Ruitenbeek, J., Personal communication, June 30, 2012.
20. This report, *Estimating Ecosystem Services in Southern Ontario,* is based on benefit transfer techniques and was produced for the Ontario Ministry of Natural Resources (OMNR). Limitations and caveats associated with the original study include constraints related to the benefits transfer approach and assumptions made to address data gaps. Scale of analysis is also important in this type of work, since values are transferred from one site to another. The OMNR plans to update the Troy and Bagstad values as new primary data becomes available. For more information, see Troy and Bagstad (2009).
21. The MEGS project used the dollars per hectare values from the Troy and Bagstad (2009) report to calculate estimates for the Thousand Islands National Park as a starting point for the monetary valuation of annual EGS flows from the park area.
22. The value of these EGS is an underestimate since some EGS were not assessed for each land cover type in the Troy and Bagstad (2009) study, due to the lack of relevant studies for benefit transfer.

Table 4.3
Annual ecosystem service flows, by land cover type and selected land cover compilation, Thousand Islands National Park

	Area-weighted average value per hectare [2]	Land cover compilation											
		Troy and Bagstad GIS, 15 m, 2008		AAFC land cover, 30 m, 2011		CCRS land cover, 250 m, 2011		SOLRIS, 15 m, 2008		MEGS geospatial database, 250 m [1], 2011		Parks Canada LANDSAT-TM, 30 m, 2007	
		land cover	valuation [3]	land cover	valuation	land cover	valuation	land cover	valuation	land cover	valuation	land cover	valuation
	dollars	percent	dollars	percent	dollars	percent	dollars	percent	dollars	percent	dollars	percent	dollars
Total		**100.0**	**14,669,989**	**100.0**	**13,793,498**	**100.0**	**14,192,366**	**100.0**	**13,611,446**	**100.0**	**14,030,681**	**100.0**	**12,492,976**
Forest	4,776	68.9	7,334,476	82.0	8,733,404	76.8	8,170,562	71.7	7,629,237	71.9	7,655,654	82.4	8,775,725
Shrubland [4]	0	0.0	0	1.2	0	1.4	0	0.0	0	1.4	0	3.3	0
Grassland	377	0.8	7,049	0.0	0	5.9	49,210	0.0	0	8.3	69,541	0.0	0
Barrenland [5]	0	0.0	0	0.3	0	0.0	0	10.1	0	0.0	0	0.0	0
Wetland	15,908	18.5	6,557,799	11.3	3,994,971	5.1	1,794,411	16.2	5,757,333	11.0	3,890,792	10.0	3,551,735
Cropland and field	151	8.7	29,176	1.8	6,004	1.1	3,799	0.7	2,197	0.6	2,111	1.7	5,593
Built-up [6]	0	1.3	0	0.9	0	0.0	0	0.8	0	1.1	0	2.2	0
Water snow ice	19,081	1.7	741,489	2.5	1,059,119	9.8	4,174,384	0.5	222,679	5.7	2,412,584	0.4	159,923

1. Base layer of the geodatabase is 250 m; additional datasets improve overall resolution.
2. The Troy and Bagstad (2009) report estimated EGS monetary values by land cover; however, their categories differ from the land cover classes used in the MEGS project. For this reason, area-weighted averages of the Troy and Bagstad monetary values were applied to the various MEGS land cover types, from each land cover compilation.
3. These valuation estimates are based on the land cover categories and values per hectare compiled by Troy and Bagstad (2009) and are not as sensitive to land cover concordance and roll-up limitations as the other land cover compilation sources used in this analysis.
4. Shrubland does not exist as a distinct land cover class in the Troy and Bagstad (2009) report and monetary values are not provided for this land class. As a result, the total monetary valuation may be underestimated for the AAFC, CCRS, MEGS geospatial database and the Parks Canada LANDSAT-TM land cover compilations, which did attribute a proportion of the land cover to shrubland.
5. Barrenland does not exist as a distinct land cover class in the Troy and Bagstad (2009) report and monetary values are not provided for this land class. As a result, the total monetary valuation may be underestimated for the AAFC and the SOLRIS land cover compilations, which did attribute a proportion of the land cover to barrenland.
6. Built-up areas (including greenspace) were not valued; this land class was considered inappropriate for a study in a National Park.

Note(s): Monetary values, in 2012 Canadian dollars, represent annual flows of EGS per year and exclude real-estate values. Monetary estimates are associated only with the Thousand Islands National Park area. The value of these EGS is an underestimate since some EGS were not assessed for each land cover type in the Troy and Bagstad (2009) study, due to the lack of relevant studies for benefit transfer.

Source(s): Troy, A. and K. Bagstad, 2009, *Estimating Ecosystem Services in Southern Ontario,* Ontario Ministry of Natural Resources. Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011,* Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Ontario Ministry of Natural Resources, Science and Information Branch, 2008, *Southern Ontario Land Resource Information System (SOLRIS)*. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation. Parks Canada, Natural Resource Conservation, 2012, special tabulation, Land Cover Map of the Greater Thousand Islands National Park Ecosystem using Landsat Thematic Mapper and Random Forest Models, LANDSAT 5.

The data source used to identify land cover statistics has an impact on the monetary valuations of EGS estimated for the Thousand Islands National Park. The available image resolution and land cover classification must be evaluated before selecting the best-suited data source for valuation exercises.

4.3.2 Valuation of individual ecosystem goods and services by land cover type

Selected ecosystem services values were estimated, specifically, the value of the park's recreation services as well as option, bequest and existence values associated with the park's wetland areas, which make up 10% of the park area.

Applying benefit transfer concepts, annual recreational services for all land cover types present in the national park were valued at $3.9 million (2012 dollars), while annual option, bequest and existence values of the park's wetland area ranged from approximately $434,000 to $530,800 (2012 dollars).[23]

These values are of significance to park managers—they help illustrate the benefits the park provides to visitors and also to those who simply benefit from knowing the park exists. While this experimental valuation effort focused on only a few of the EGS types provided by the park, it shows that the park has value that can be expressed in monetary terms, beyond the monies collected at the park gate.

23. These figures are likely an underestimate of option, bequest and existence values of park wetland areas for two reasons. Firstly they take account of values held by households living in close proximity to the park only (within 55 km). Secondly, they exclude values held by individuals who live in the United States.

It is important to note that EGS values can be represented through non-monetary techniques as well. For example, the value of a park area can be put in context with information about the number and characteristics of the people living nearby, without putting an actual dollar figure on the EGS.

Section 5

Moving forward—a research agenda

This report presents some of the results from the Measuring Ecosystem Goods and Services (MEGS) project. The objective of MEGS was to scope out the requirements for producing and analyzing comprehensive statistics on ecosystems and their goods and services (see Textbox 1). The focus was to begin building the infrastructure, develop, and apply classifications, quality measures and valuation methods to further the development of ecosystem accounts in a manner consistent with existing international initiatives and recommendations.

These objectives were achieved, with several notable accomplishments noted below:

1. **MEGS geodatabase**
   - The technical work to reconcile existing publicly-available spatial datasets was a fundamental part of the MEGS project and will help support future research and development in this field. Many of the results presented in this report relied on the development of this MEGS geodatabase (Appendix A). For example, Canadian valuation studies from the Environmental Valuation Reference Inventory (EVRI) database and elsewhere were integrated into the geodatabase and were used in valuation of selected ecosystem goods and services (EGS) flows for the Thousand Islands National Park. Census of Population data were integrated and supported production of the marine coastal ecumene and the Golden Horseshoe analysis.

2. **Developing and applying new ecosystem accounting concepts**
   - The MEGS project was conducted concurrently with international initiatives to develop concepts and methods for ecosystem accounting, in particular, the System of Environmental-Economic Accounts (SEEA): Experimental Ecosystem Accounting. The MEGS team adopted and refined the land cover ecosystem unit (LCEU) concept from SEEA, adding the dimensions of terrain elevation and ruggedness, and measured the concept in Canada (see Appendix A). Tracking the state of LCEU over time will help identify trends in the production of EGS in Canada.
   - The project identified and applied non-monetary valuation methodologies, resulting in contextual information about the value of wetlands EGS in Canada. This information was organized using an accounting approach, meeting another key objective of MEGS.

3. **Land cover change matrix**
   - Tracking changes in land cover and land use is a useful starting point for studying the state of terrestrial ecosystems. The MEGS project produced a land cover change matrix (Table 3.2: Land cover, southern Canada, 2000 to 2011), which identified the major changes in land cover between these two years.

Arguably one of the most important achievements of this interdepartmental initiative in ecosystem accounting is the identification of limitations and issues in both the data and the statistical infrastructure (e.g., concepts, classifications and dissemination tools). Moving forward, ecosystem accounting, in Canada and elsewhere, will have to tackle the following issues:

1. **Spatial datasets**
   - Regularly updated spatial datasets such as land cover, land use, climate and species distribution provide information that is essential to assess and value EGS and compare changes over time. Although datasets have improved over the years, several limitations remain. For example, existing national land cover datasets may under or over estimate particular categories. Also, efforts could be made to identify priority ecosystems—and ensure that land cover datasets are developed to accurately represent these areas.
   - Other datasets, such as fish and game abundance and distribution, could be improved through enhanced coordination between government departments, environmental non-government organizations, academia and civil society. In other instances, comprehensive information is simply not available, such as pollinator distribution and abundance, and measures of soil quality.
   - Spatial resolution is also an important consideration—geospatial inventories should be created at a resolution that allows for flexibility in the scale of analysis, whether it is local, regional, national or global. Finer resolution datasets would allow for more flexible and comprehensive analysis.

2. **Development of indicators**
   - Further work is required to integrate the different aspects of the human landscape modification measures into a composite indicator. This includes identifying the most appropriate elements to include in the indicator and assigning appropriate weights—or relative values in the equation—to the various components.
   - Also required are sound indicators that make the link between ecosystem stocks (volume and condition) and the flows of EGS that are produced by those stocks, establishing the biophysical connection between the quality of the environment and the benefits that people derive from it.
   - Additional research is also necessary to improve analysis and indicators for ecosystem potential. Also, investigating a net carbon balance indicator is seen as the next step for the work done on biomass extraction.

3. **Characterization of EGS for marine and coastal ecosystems**
   - During the project, ecodistricts dependent on marine and coastal EGS were identified using data on employment in the fishing, seafood processing and aquaculture sectors, thereby delineating the marine coastal fisheries ecumene. An important step to follow-up on this accomplishment would be to develop a detailed classification for coastal and marine ecosystems and their associated goods and services at an appropriate scale, and to link them back to the spatial distribution of socio-economic activities supported by these coastal and marine ecosystems.
   - Further work is also required to improve the understanding of coastal and marine ecosystems, especially their functions, their quality and how these relate to their potential to generate EGS, including the development of quantitative metrics of ecosystem components and functions. Some of this information has already been compiled during the MEGS project, but will have to be built upon to develop a complete set of accounts.

4. **Case studies**
   - Case studies such as those presented in this report could be developed for other areas, for example other national parks, built-up and agricultural areas, and northern ecosystems. Also, further investment is required to go into more depth in analyzing specific EGS, including cultural services; work to develop this kind of analysis will also seek to include measures of quality.
   - It would be helpful to better apply an accounts structure to the case studies, linking the flow of EGS to stock of natural capital assets, such as the one proposed by the SEEA: Experimental Ecosystem Accounting.

5. **Valuation of EGS flows**
   - Non-monetary valuation, an approach that uses bio-physical and socio-economic contextual information, is a useful complement to the assessment of EGS in monetary values. This contextual information in and of itself provides perspective on the benefits provided by EGS. There is a role for national statistical offices in helping to understand the non-monetary values of EGS flows.
   - Monetary valuation of EGS can be both difficult and controversial; nonetheless, it is a useful tool for gauging the relative significance of EGS and for linking ecosystem accounts to the broader national accounting framework. Keeping monetary valuation as an end goal can help ensure the existence of appropriate data required by researchers who wish to develop value estimates. National statistical offices have a role to play in producing the underlying data and the statistical infrastructure including classifications, the accounting structure, data collection processes and indicators that allow the estimation of monetary values.

6. **Natural capital asset boundaries**
   - An important feature of ecosystem accounting is how accounts can be developed using SEEA recommendations, which would allow for international comparability and links to the System of National Accounts. In order to do this, it is necessary to establish both the list of natural capital assets, the list of EGS that are to be included, and determine who the beneficiaries are. Such a classification of the systematic grouping of stocks and flows is imperative in order to settle what is to be included in the ecosystem accounts, and would allow the comparability of EGS values through time and across boundaries.
   - The Thousand Islands National Park case study provides monetary estimates of annual EGS flows. Identifying the values of the stocks of natural assets generating EGS flows is within reach; one of the main challenges is choosing an appropriate discount rate.[1]

Although the above is a partial listing of topics, this research agenda demonstrates the extent and diversity of themes that still need to be explored in order to properly account for EGS. As a new discipline, ecosystem accounting draws from the knowledge and experience acquired during the recent development of environmental accounting, but requires continued collaboration among the various disciplines and departments if it is to become the analytical system that it promises to be.

1. United Nations Statistics Division, 2013, *The System of Environmental-Economic Accounting (SEEA): SEEA Experimental Ecosystem Accounting,* (Draft subject to final editing), *http://unstats.un.org/unsd/statcom/doc13/BG-SEEA-Ecosystem.pdf* (accessed August 14, 2013).

Appendix A

Measuring Ecosystem Goods and Services geodatabase

The Measuring Ecosystem Goods and Services (MEGS) geodatabase includes several publicly available spatial datasets, facilitating access to integrated biophysical data, such as land cover, elevation, climate, as well as socio-economic data, such as land use and income, for the entire country (Table 1, Appendix A).

Table 1
Measuring Ecosystem Goods and Services geodatabase datasets and sources

Datasets	Source
Canada 250m Land Cover Time Series 2000 to 2011	Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector,Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013).
V2.2 Soil Landscape Units	Agriculture and Agri-Food Canada, 2013, *Soil Landscape of Canada version 2.2*, *http://sis.agr.gc.ca/cansis/nsdb/slc/v2.2/index.html*, (accessed October 9, 2013).
2006 Settlement boundaries, Statistics Canada, Environment Accounts and Statistics Division	Statistics Canada, Environment Accounts and Statistics Division, special tabulation.
2011 Road Network File	Statistics Canada, 2011, *Road Network File, 2011,* Catalogue no. 92-500-X.
CANVEC hydrographic features layer, 2010	Natural Resources Canada, 2012, *CanVec*, Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, *www.geogratis.gc.ca* (accessed March 1, 2012).
CANVEC wetland features layer, Natural Resources Canada, 2010	Natural Resources Canada, 2012, *CanVec*, Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, *www.geogratis.gc.ca* (accessed March 1, 2012).
Canadian Ecodistrict Climate Normals, 1960 to 1990	Agriculture and Agri-Food Canada, 2013, *Canadian Ecodistrict Climate Normals 1961-1990*, *http://sis.agr.gc.ca/cansis/nsdb/ecostrat/district/climate.html* (accessed October 9, 2013).
Census of Population, Statistics Canada, various years	Statistics Canada, Environment Accounts and Statistics Division, special tabulation.
Canada Digital Elevation Model, 800 metres	Natural Resources Canada, 2000, *Canadian Digital Elevation Data*, Earth Sciences Sector, Centre for Topographic Information, *www.geobase.ca/geobase/en/data/cded/index.html* (accessed September 12, 2013).

The 250 m resolution[1] 25 class land cover data produced annually since 2001 by the Canada Centre for Remote Sensing (CCRS) using Moderate Resolution Imaging Spectroradiometer (MODIS) forms the base land cover layer of the MEGS geodatabase.

1. The 250 m resolution land cover data overlays the whole country with a 250 m x 250 m grid. These grid cells are the MEGS basic statistical units, or BSU. Features or objects smaller than 250 m will have a weak resolution while larger items would have a better resolution. For this reason, large forests are clearly identified while small wetlands and potholes are less identified.

The advantages of using the CCRS land cover data are:

- it is a publicly available national dataset
- it covers the whole Canadian landmass
- it is produced on an annual basis using consistent parameters allowing for temporal change analysis.

The disadvantages of using CCRS land cover data are:

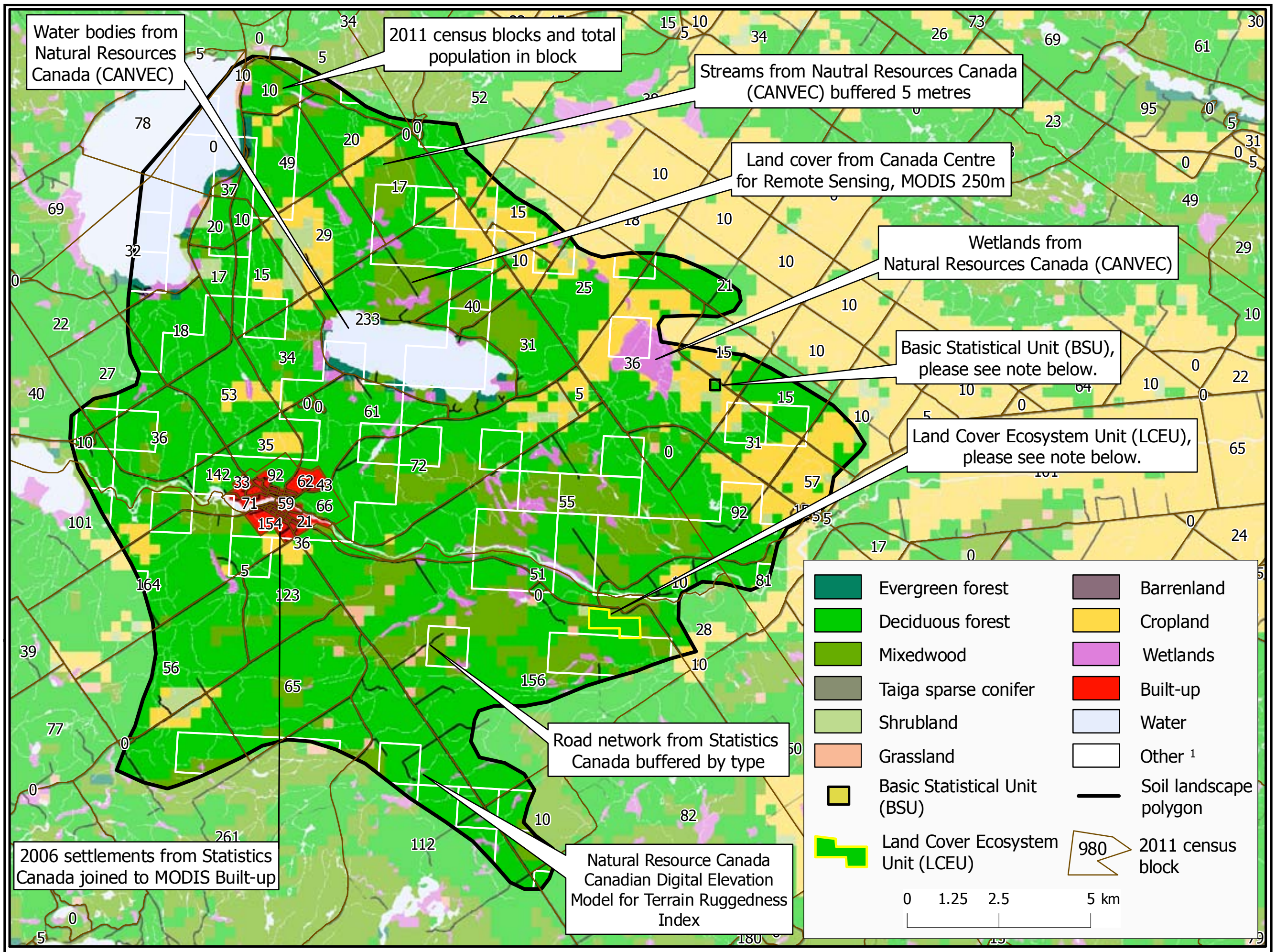
- identification of land cover types other than forest cover (e.g., wetlands) is less consistent
- the 250 m resolution does not provide detailed spatial accuracy for smaller objects or features (e.g., roads and highways).

Several other spatial data sources were integrated and reconciled with the CCRS land cover to develop a consolidated MEGS geodatabase. Added datasets available at the national scale include Natural Resources Canada's CanVec hydrographic and wetlands geospatial datasets[2] and Statistics Canada's Road Network (2011)[3] and Settlements spatial dataset,[4] which depicts where people are settled. Socio-economic information from the 2006 and 2011 Census of Population and Census of Agriculture were also included. Environment Canada's 1961 to 1990 climate normals (e.g., temperature and precipitation) by ecodistrict and Agriculture and Agri-Food Canada's (AAFC) soil component tables (e.g., soil composition, parent material, and slope) at the soil landscape unit were also consolidated.

These datasets were added as geocoded layers on top of the original CCRS dataset. By undertaking a series of overlay analyses using the capabilities of a geographic information system (GIS), information from these datasets was used to complement the original land cover classifications found in the MODIS product where appropriate (Map 1, Appendix A). The additions add relevant information to the CCRS dataset, enhancing its utility for land cover analysis. Other datasets that do not span the entire landmass of Canada but are of value to MEGS were also integrated. For example, it included the AAFC 30 m land cover dataset, which was used in section 3.1 to study land cover change.

2. Natural Resources Canada, 2013, *CanVec*, Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, *www.geogratis.gc.ca* (accessed July 17, 2013).
3. Statistics Canada, 2011, *Road Network File, 2011*, Catalogue no. 92-500-X.
4. Statistics Canada, 2010, "Introducing a New Concept and Methodology for Delineating Settlement Boundaries: A Research Project on Canadian Settlements," *Environment Accounts and Statistics Analytical and Technical Paper Series*, Catalogue no. 16-001-M, no. 11.

Map 1
Measuring Ecosystem Goods and Services geodatabase



1. Combines Canada Centre for Remote Sensing (CCRS) land cover codes for snow and ice.

Note(s): This map illustrates certain datasets and statistical units used in the MEGS geodatabase. Individual pixels display the 250 m resolution land cover data produced by the Canada Centre for Remote Sensing. These pixels are the Basic Statistical Units (BSU) that can be aggregated together based on their land cover type, elevation and ruggedness, to form what is called the Land Cover Ecosystem Units (LCEU); LCEU are one way to represent ecosystems spatially. The MEGS geodatabase provides further attribute information such as climatic and socio-economic data for each of these units. These units can be rolled-up into the spatial accounting units presented in Figure 1 (Appendix A). The map also illustrates some of the various other datasets that have been integrated in the MEGS geodatabase.

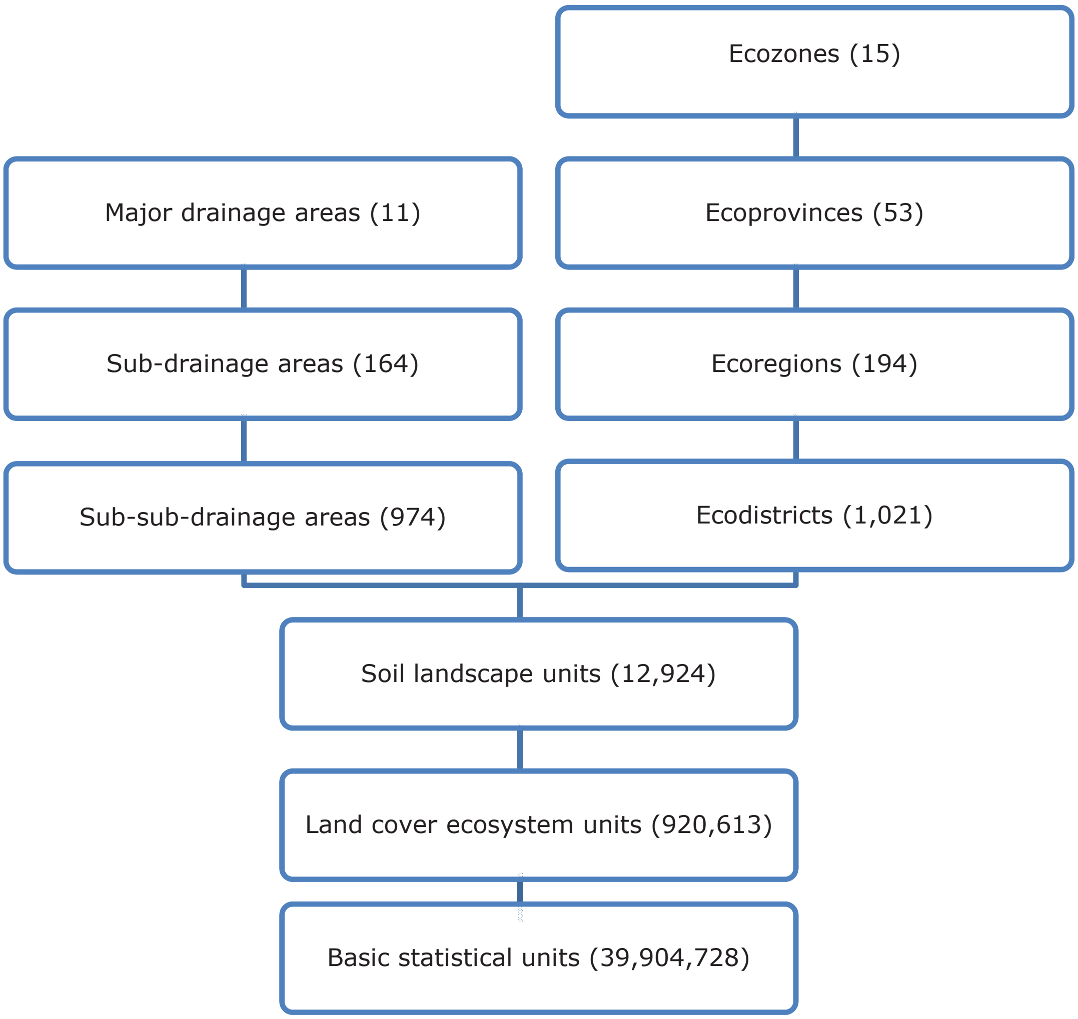
Source(s): Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing, ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/ (accessed May 8, 2013). Natural Resources Canada, 2012, *CanVec*, Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, www.geogratis.gc.ca (accessed March 1, 2012). Statistics Canada, 2011, *Road Network File, 2011*, Catalogue no. 92-500-X. Natural Resources Canada, 2000, *Canadian Digital Elevation Data*, Earth Sciences Sector, Centre for Topographic Information, www.geobase.ca/geobase/en/data/cded/index.html (accessed September 12, 2013). Statistics Canada, 2011 Census of Population. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Measuring Ecosystem Goods and Services spatial hierarchy

MEGS uses both the ecozone and the drainage area hierarchies as the reporting and accounting framework for the outputs from the geodatabase (see Appendix H Geographies). Ecozones and major drainage areas aggregate data provided at lower levels of geography. Figure 1 (Appendix A) illustrates the various levels of the MEGS spatial hierarchy.

Figure 1

Measuring Ecosystem Goods and Services spatial hierarchy and accounting units



Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013.

The lowest level of accounting unit in the MEGS geographic hierarchy, the basic statistical unit (BSU), is the smallest spatial unit available for the entire landmass, currently provided by MODIS.

MEGS aggregates the BSU and associated data into land cover ecosystem units (LCEU), which are the statistical proxy of terrestrial ecosystems.[5] Although ecosystems cannot be defined purely in spatial terms, combining land cover, elevation and terrain ruggedness data with other datasets provides a reasonable surrogate measure to differentiate between ecosystems.

LCEUs represent common biophysical characteristics, and as such are valuable for studying the impact of human activities on the environment, including socio-economic and environmental analyses.

A digital elevation model was used as an input into the elevation classification and terrain ruggedness index calculation,[6] providing data for each individual BSU. Once the elevation and terrain ruggedness index attributes have been added to a BSU, adjacent areas with the same land cover type, elevation and ruggedness are grouped together to form distinct LCEUs. This added layer of information can help further define important land cover characteristics that are otherwise not provided by MODIS.

In Canada, there are 420 distinct types of LCEU, with the most common type being Water, followed by Wetlands and Evergreen forest (Table 2, Appendix A).

Table 2
Top 20 land cover ecosystem units in Canada

	Count	Land cover	Elevation	Terrain ruggedness index	Area (km^2)	Percent
1	13,215	Water natural and artificial	Plain	Moderately rugged surface	104,902.6	1.1
2	12,438	Water natural and artificial	Plain	Extremely rugged surface	68,196.3	0.7
3	12,154	Water natural and artificial	Plain	Highly rugged surface	54,511.0	0.6
4	11,425	Water natural and artificial	Lowland	Moderately rugged surface	100,814.1	1.0
5	11,082	Water natural and artificial	Plain	Intermediately rugged surface	66,329.1	0.7
6	10,869	Water natural and artificial	Lowland	Highly rugged surface	58,217.6	0.6
7	10,648	Water natural and artificial	Lowland	Extremely rugged surface	37,206.0	0.4
8	9,741	Water natural and artificial	Lowland	Intermediately rugged surface	53,631.4	0.5
9	9,617	Water natural and artificial	Plain	Slightly rugged surface	52,258.9	0.5
10	9,563	Wetland	Plain	Moderately rugged surface	48,421.0	0.5
11	9,045	Evergreen forest	Hill	Extremely rugged surface	368,372.2	3.7
12	8,813	Wetland	Lowland	Moderately rugged surface	63,733.6	0.7
13	8,743	Water natural and artificial	Plain	Level terrain surface	271,280.9	2.8
14	8,694	Water natural and artificial	Lowland	Slightly rugged surface	37,255.8	0.4
15	8,657	Water natural and artificial	Plain	Nearly level surface	49,254.3	0.5
16	8,375	Water natural and artificial	Hill	Extremely rugged surface	26,964.3	0.3
17	8,288	Evergreen forest	Lowland	Moderately rugged surface	181,858.8	1.8
18	8,244	Evergreen forest	Lowland	Extremely rugged surface	152,162.2	1.5
19	8,123	Wetland	Plain	Intermediately rugged surface	50,428.9	0.5
20	7,742	Water natural and artificial	Lowland	Nearly level surface	31,743.2	0.3

Source(s): Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

5. United Nations Statistics Division, 2013, *The System of Environmental-Economic Accounting (SEEA): SEEA Experimental Ecosystem Accounting*, (Draft subject to final editing), *http://unstats.un.org/unsd/statcom/doc13/BG-SEEA-Ecosystem.pdf* (accessed August 14, 2013).
6. Produced by the Canadian Forestry Service, Ontario region.

Appendix B

Monetary valuation methods

A variety of methods can be used to estimate the monetary value of ecosystem goods and services (EGS), each with its own advantages and limitations. Different methods can be applied based on the type of policy use and amount of resources available to practitioners. Monetary valuation is often classified according to the following three categories:[1]

1. Revealed preference methods use observations of individuals' choices in existing markets to estimate monetary values of goods and services. Individuals are said to 'reveal' their preferences through their choices; for example, travel costs can be used to estimate willingness to pay for recreational services. Similarly, real estate market data comparing property values close to and far from parks can be used to measure the value individuals place on this amenity.

2. Market-based approaches, a subset of revealed preference, rely on direct, observable market interactions to estimate monetary values of goods and services. For example, market prices may be used to estimate the value of EGS that are not traded in a market (e.g., non-marketed timber, forest products and fish). Costs that would have been incurred in the absence of an ecosystem service can be used to estimate EGS values (e.g., flood prevention services). Similarly, the costs of substitutes, required mitigation or restoration expenses can be used as indicators of the value of EGS.

3. Stated preference valuation methods gather information concerning environmental preferences through the use of surveys, questionnaires, or interviews. For example, the contingent valuation method, asks people's willingness to pay for improved environmental protection or to accept compensation for a reduction in environmental quality.

Benefit transfer or value transfer is a secondary approach that can be used when site-specific information is not available. This approach transfers existing valuation work from well-studied sites to new areas, as an alternative to conducting original research at the new site. Value transfer is discussed in more detail in Section 4, textbox 3.

Monetary valuation techniques—like non-monetary valuation, physical ecosystem function and services measurements and mapping techniques—are affected by uncertainty. This stems from gaps in knowledge about ecosystem dynamics, human preferences and technical issues in the valuation process. Where ecosystems are assessed or studied using any of these methods, acknowledging uncertainty and limitations in the techniques used is important.[2]

1. Pascual, U., R. Muradian, L. Brander, E. Gómez-Baggethun, B. Martín-López, M. Verma, P. Armsworth, M. Christie, H. Cornelissen, F. Eppink, J. Farley, J. Loomis, L. Pearson, C. Perrings and S. Polasky, 2010, "Chapter 5: The economics of valuing ecosystem services and biodiversity," pages 183 to 255 in Kumar, P. (ed.), 2010, *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*, Earthscan, London and Washington.
2. Pascual et al., 2010.

Appendix C

Land cover change coverage and detailed human landscape modification tables

Map 1
Coverage for the land cover change analysis, southern Canada

Source(s): Agriculture and Agri-Food Canada, 2009, *Land Cover for Agricultural Regions of Canada (circa 2000)*, version 12, http://data.gc.ca/data/en/dataset/f5ded3b0-a5b4-4599-95d6-d853a825792b (accessed October 9, 2012). Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada,* ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/ (accessed October 9, 2012). McNiven C. and H. Puderer, 2000, "Delineation of Canada's North: An Examination of the North-South Relationship in Canada," *Geography Working Paper Series*, Statistics Canada Catalogue no. 92F0138M2000003. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Table 1
Population by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Area [1]	Population		Population density		Population and population density
			2001	2011	2001	2011	Change 2001 to 2011
	code	square kilometres	persons		persons per square kilometre		percent
Canada	...	**8,864,779**	**30,007,094**	**33,476,688**	**3.4**	**3.8**	**11.6**
Saint John and Southern Bay of Fundy, New Brunswick	01A	40,415	403,908	413,990	10.0	10.2	2.5
Gulf of St. Lawrence and Northern Bay of Fundy, New Brunswick	01B	59,928	447,196	452,765	7.5	7.6	1.2
Prince Edward Island	01C	5,521	135,294	140,204	24.5	25.4	3.6
Bay of Fundy and Gulf of St. Lawrence, Nova Scotia	01D	20,686	316,326	319,417	15.3	15.4	1.0
Southeastern Atlantic Ocean, Nova Scotia	01E	21,213	444,428	466,559	21.0	22.0	5.0
Cape Breton Island	01F	9,683	147,454	135,933	15.2	14.0	-7.8
Northwestern Lake Superior	02A	36,769	132,443	131,349	3.6	3.6	-0.8
Northeastern Lake Superior	02B	37,526	46,213	42,043	1.2	1.1	-9.0
Northern Lake Huron	02C	31,651	253,414	257,964	8.0	8.2	1.8
Wanapitei and French, Ontario	02D	16,888	90,066	92,832	5.3	5.5	3.1
Eastern Georgian Bay	02E	19,797	682,531	796,438	34.5	40.2	16.7
Eastern Lake Huron	02F	14,640	307,502	314,290	21.0	21.5	2.2
Northern Lake Erie	02G	22,332	2,032,283	2,204,745	91.0	98.7	8.5
Lake Ontario and Niagara Peninsula	02H	27,230	6,368,060	7,394,483	233.9	271.6	16.1
Upper Ottawa	02J	45,495	111,566	109,703	2.5	2.4	-1.7
Central Ottawa	02K	37,445	428,524	475,802	11.4	12.7	11.0
Lower Ottawa	02L	50,654	1,192,671	1,373,928	23.5	27.1	15.2
Upper St. Lawrence	02M	4,931	255,710	272,852	51.9	55.3	6.7
Saint-Maurice	02N	38,133	126,360	125,895	3.3	3.3	-0.4
Central St. Lawrence	02O	33,754	4,516,643	4,989,375	133.8	147.8	10.5
Lower St. Lawrence	02P	36,386	1,155,141	1,247,461	31.7	34.3	8.0
Northern Gaspé Peninsula	02Q	13,102	129,570	128,780	9.9	9.8	-0.6
Saguenay	02R	81,115	279,079	276,001	3.4	3.4	-1.1
Betsiamites, coast	02S	24,870	14,583	13,750	0.6	0.6	-5.7
Manicouagan and aux Outardes	02T	57,617	19,667	17,822	0.3	0.3	-9.4
Moisie and St. Lawrence Estuary	02U	36,340	49,334	49,145	1.4	1.4	-0.4
Gulf of St. Lawrence, Romaine	02V	33,684	1,802	1,483	0.1	0 s	-17.7
Gulf of St. Lawrence, Natashquan	02W	48,023	19,631	19,418	0.4	0.4	-1.1
Petit Mécatina and Strait of Belle Isle	02X	46,486	5,708	5,229	0.1	0.1	-8.4
Northern Newfoundland	02Y	55,187	164,030	155,994	3.0	2.8	-4.9
Southern Newfoundland	02Z	44,262	321,036	331,797	7.3	7.5	3.4
Nottaway, coast	03A	61,867	25,339	23,793	0.4	0.4	-6.1
Broadback and Rupert	03B	65,798	4,867	6,345	0.1	0.1	30.4
Eastmain	03C	39,065	613	767	0 s	0 s	25.1
La Grande, coast	03D	88,294	4,967	6,132	0.1	0.1	23.5
Grande rivière de la Baleine, coast	03E	52,071	1,333	1,531	0 s	0 s	14.9
Eastern Hudson Bay	03F	36,510	348	444	0 s	0 s	27.6
Northeastern Hudson Bay	03G	80,973	3,053	3,904	0 s	0 s	27.9
Western Ungava Bay	03H	68,544	2,647	3,338	0 s	0 s	26.1
Aux Feuilles, coast	03J	54,114	387	638	0 s	0 s	64.9
Koksoak	03K	41,161	1,932	2,235	0 s	0.1	15.7
Caniapiscau	03L	73,410	1,252	1,360	0 s	0 s	8.6
Eastern Ungava Bay	03M	93,712	710	900	0 s	0 s	26.8
Northern Labrador	03N	83,696	2,897	3,242	0 s	0 s	11.9
Churchill, Newfoundland and Labrador	03O	75,816	13,966	13,241	0.2	0.2	-5.2
Central Labrador	03P	33,020	6,288	6,400	0.2	0.2	1.8
Southern Labrador	03Q	35,166	2,717	2,204	0.1	0.1	-18.9
Hayes, Manitoba	04A	95,416	10,442	13,043	0.1	0.1	24.9
Southwestern Hudson Bay	04B	27,719	0	0	0.0	0.0	...
Severn	04C	89,393	5,763	5,093	0.1	0.1	-11.6
Winisk, coast	04D	71,550	2,615	237	0 s	0 s	-90.9
Ekwan, coast	04E	48,501	0	0	0.0	0.0	...
Attawapiskat, coast	04F	53,749	1,962	425	0 s	0 s	-78.3
Upper Albany	04G	56,889	2,106	1,443	0 s	0 s	-31.5
Lower Albany, coast	04H	41,392	441	2,031	0 s	0 s	360.5
Kenogami	04J	49,822	8,144	6,799	0.2	0.1	-16.5

See notes at the end of the table.

Table 1 – continued

Population by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Area [1]	Population		Population density		Population and population density
			2001	2011	2001	2011	Change 2001 to 2011
	code	square kilometres	persons		persons per square kilometre		percent
Moose, Ontario	04K	17,539	2,886	3,852	0.2	0.2	33.5
Missinaibi and Mattagami	04L	58,273	62,046	57,879	1.1	1.0	-6.7
Abitibi	04M	27,296	46,009	43,125	1.7	1.6	-6.3
Harricanaw, coast	04N	41,898	57,683	57,810	1.4	1.4	0.2
Upper South Saskatchewan	05A	45,618	233,081	266,878	5.1	5.9	14.5
Bow	05B	25,014	1,024,550	1,313,058	41.0	52.5	28.2
Red Deer	05C	49,105	223,841	265,648	4.6	5.4	18.7
Upper North Saskatchewan	05D	27,562	345,670	439,197	12.5	15.9	27.1
Central North Saskatchewan	05E	40,358	746,409	889,643	18.5	22.0	19.2
Battle	05F	29,471	118,085	130,578	4.0	4.4	10.6
Lower North Saskatchewan	05G	47,814	99,848	99,464	2.1	2.1	-0.4
Lower South Saskatchewan	05H	53,709	290,050	324,195	5.4	6.0	11.8
Qu'Appelle	05J	72,879	317,644	333,203	4.4	4.6	4.9
Saskatchewan	05K	68,068	63,854	64,292	0.9	0.9	0.7
Lake Winnipegosis and Lake Manitoba	05L	67,799	86,220	82,868	1.3	1.2	-3.9
Assiniboine	05M	49,558	342,337	345,025	6.9	7.0	0.8
Souris	05N	38,642	68,105	69,291	1.8	1.8	1.7
Red	05O	25,093	640,410	717,652	25.5	28.6	12.1
Winnipeg	05P	44,575	56,269	56,068	1.3	1.3	-0.4
English	05Q	42,921	28,487	26,718	0.7	0.6	-6.2
Eastern Lake Winnipeg	05R	51,430	5,181	4,665	0.1	0.1	-10.0
Western Lake Winnipeg	05S	24,109	29,318	32,851	1.2	1.4	12.1
Grass and Burntwood	05T	37,234	17,841	17,523	0.5	0.5	-1.8
Nelson	05U	42,474	10,773	14,062	0.3	0.3	30.5
Beaver, Alberta and Saskatchewan	06A	45,427	57,887	63,563	1.3	1.4	9.8
Upper Churchill, Manitoba	06B	37,977	8,203	9,298	0.2	0.2	13.3
Central Churchill, upper, Manitoba	06C	37,264	10,427	11,833	0.3	0.3	13.5
Reindeer	06D	49,408	3,159	3,656	0.1	0.1	15.7
Central Churchill, lower, Manitoba	06E	41,131	5,554	4,857	0.1	0.1	-12.5
Lower Churchill, Manitoba	06F	48,593	963	813	0 s	0 s	-15.6
Seal, coast	06G	64,609	316	321	0 s	0 s	1.6
Western Hudson Bay, Southern	06H	57,545	0	0	0.0	0.0	...
Thelon	06J	71,534	0	0	0.0	0.0	...
Dubawnt	06K	50,146	0	0	0.0	0.0	...
Kazan	06L	53,557	0	0	0.0	0.0	...
Chesterfield Inlet	06M	56,140	1,507	1,872	0 s	0 s	24.2
Western Hudson Bay, central	06N	50,400	4,726	5,304	0.1	0.1	12.2
Western Hudson Bay, northern	06O	48,706	0	0	0.0	0.0	...
Hudson Bay, Southampton Island	06P	42,856	1,396	1,646	0 s	0 s	17.9
Foxe Basin, Southampton Island	06Q	12,034	0	0	0.0	0.0	...
Foxe Basin, Melville Peninsula	06R	53,167	2,507	2,945	0 s	0.1	17.5
Foxe Basin, Baffin Island	06S	179,071	0	0	0.0	0.0	...
Hudson Strait, Baffin and Southampton Islands	06T	40,824	1,581	1,818	0 s	0 s	15.0
Upper Athabasca	07A	34,532	40,805	43,284	1.2	1.3	6.1
Central Athabasca, upper	07B	38,546	57,292	59,482	1.5	1.5	3.8
Central Athabasca, lower	07C	53,893	35,508	38,192	0.7	0.7	7.6
Lower Athabasca	07D	28,493	17,310	38,713	0.6	1.4	123.6
Williston Lake	07E	69,583	6,223	4,443	0.1	0.1	-28.6
Upper Peace	07F	67,345	75,434	80,019	1.1	1.2	6.1
Smoky	07G	50,965	78,233	102,125	1.5	2.0	30.5
Central Peace, upper	07H	34,741	14,607	15,126	0.4	0.4	3.6
Central Peace, lower	07J	57,427	19,294	22,420	0.3	0.4	16.2
Lower Peace	07K	33,745	1,623	2,333	0 s	0.1	43.7
Fond-du-Lac	07L	56,953	1,946	2,205	0 s	0 s	13.3
Lake Athabasca, shores	07M	28,777	1,293	1,157	0 s	0 s	-10.5
Slave	07N	16,013	2,206	2,133	0.1	0.1	-3.3
Hay	07O	50,598	5,497	5,822	0.1	0.1	5.9
Southern Great Slave Lake	07P	32,274	1,256	580	0 s	0 s	-53.8
Great Slave Lake, east arm, south shore	07Q	80,614	248	477	0 s	0 s	92.3

See notes at the end of the table.

Table 1 – continued

Population by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Area [1]	Population		Population density		Population and population density
			2001	2011	2001	2011	Change 2001 to 2011
	code	square kilometres	persons		persons per square kilometre		percent
Lockhart	07R	18,891	0	0	0.0	0.0	…
Northeastern Great Slave Lake	07S	54,174	18,195	20,034	0.3	0.4	10.1
Marian	07T	18,574	453	492	0 s	0 s	8.6
Western Great Slave Lake	07U	28,339	261	1,953	0 s	0.1	648.3
Alsek	08A	30,447	634	699	0 s	0 s	10.3
Northern coastal waters, British Columbia	08B	22,425	0	15	0.0	0 s	…
Stikine, coast	08C	49,259	912	768	0 s	0 s	-15.8
Nass, coast	08D	28,512	2,587	2,438	0.1	0.1	-5.8
Skeena, coast	08E	54,340	60,688	55,522	1.1	1.0	-8.5
Central coastal waters, British Columbia	08F	52,067	16,280	13,528	0.3	0.3	-16.9
Southern coastal waters, British Columbia	08G	40,618	620,090	687,662	15.3	16.9	10.9
Vancouver Island	08H	33,441	665,695	737,398	19.9	22.1	10.8
Nechako	08J	43,411	63,123	61,488	1.5	1.4	-2.6
Upper Fraser	08K	65,579	76,008	73,650	1.2	1.1	-3.1
Thompson	08L	54,034	172,640	185,393	3.2	3.4	7.4
Lower Fraser	08M	60,291	1,712,430	2,018,645	28.4	33.5	17.9
Columbia	08N	100,081	444,638	488,653	4.4	4.9	9.9
Queen Charlotte Islands	08O	9,533	4,935	4,370	0.5	0.5	-11.4
Skagit	08P	1,020	169	140	0.2	0.1	-17.2
Headwaters Yukon	09A	89,925	23,478	28,373	0.3	0.3	20.8
Pelly	09B	49,398	988	1,057	0 s	0 s	7.0
Upper Yukon	09C	43,157	247	293	0 s	0 s	18.6
Stewart	09D	50,561	450	507	0 s	0 s	12.7
Central Yukon	09E	29,479	1,679	1,755	0.1	0.1	4.5
Porcupine	09F	59,997	299	260	0 s	0 s	-13.0
Tanana	09H	1,450	0	0	0.0	0.0	…
Copper	09M	4,101	0	0	0.0	0.0	…
Upper Liard	10A	60,663	1,785	1,771	0 s	0 s	-0.8
Central Liard	10B	71,267	141	55	0 s	0 s	-61.0
Fort Nelson	10C	54,372	5,641	5,543	0.1	0.1	-1.7
Central Liard and Petitot	10D	29,347	0	44	0.0	0 s	…
Lower Liard	10E	54,759	988	1,008	0 s	0 s	2.0
Upper Mackenzie, Mills Lake	10F	47,671	873	890	0 s	0 s	1.9
Upper Mackenzie, Camsell Bend	10G	55,508	812	834	0 s	0 s	2.7
Central Mackenzie, Blackwater Lake	10H	65,885	638	446	0 s	0 s	-30.1
Great Bear	10J	111,659	810	890	0 s	0 s	9.9
Central Mackenzie, The Ramparts	10K	45,041	666	727	0 s	0 s	9.2
Lower Mackenzie	10L	70,009	3,638	4,121	0.1	0.1	13.3
Peel and Southwestern Beaufort Sea	10M	102,536	1,464	1,441	0 s	0 s	-1.6
Southern Beaufort Sea	10N	82,844	1,032	1,003	0 s	0 s	-2.8
Amundsen Gulf	10O	83,842	1,498	1,442	0 s	0 s	-3.7
Coppermine	10P	40,723	0	129	0.0	0 s	…
Coronation Gulf and Queen Maud Gulf	10Q	149,099	10	197	0 s	0 s	1,870.0
Back	10R	115,790	0	0	0.0	0.0	…
Gulf of Boothia	10S	103,697	1,325	1,670	0 s	0 s	26.0
Southern Arctic Islands	10T	330,254	2,781	3,401	0 s	0 s	22.3
Baffin Island, Arctic drainage	10U	281,813	9,759	11,960	0 s	0 s	22.6
Northern Arctic Islands	10V	415,472	453	349	0 s	0 s	-23.0
Missouri	11A	26,692	9,341	8,701	0.3	0.3	-6.9

1. Total area of the sub-drainage area excluding bodies of water, based on the Canada Centre for Remote Sensing (CCRS) land cover time series code 24 (open water). Figures may not add up to totals due to rounding.

Source(s): Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Statistics Canada, CANSIM table 153-0036 (accessed November 14, 2013). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Table 2
Landscape type by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natura andl naturalizing area[3]
		2001[4]			2011			Change 2001 to 2011[4]			2011		
	code	square kilometres									percent of total area[5]		
Saint John and Southern Bay of Fundy, New Brunswick	01A	735	3,666	36,014	821	3,570	36,024	86	-96	10	2.0	8.8	89.1
Gulf of St. Lawrence and Northern Bay of Fundy, New Brunswick	01B	739	1,911	57,278	786	1,954	57,188	47	42	-89	1.3	3.3	95.4
Prince Edward Island	01C	153	2,624	2,744	167	2,405	2,948	14	-218	204	3.0	43.6	53.4
Bay of Fundy and Gulf of St. Lawrence, Nova Scotia	01D	541	2,945	17,200	581	3,171	16,934	40	226	-266	2.8	15.3	81.9
Southeastern Atlantic Ocean, Nova Scotia	01E	512	839	19,862	544	706	19,963	32	-133	101	2.6	3.3	94.1
Cape Breton Island	01F	206	293	9,183	225	255	9,203	18	-38	20	2.3	2.6	95.0
Northwestern Lake Superior	02A	.	240	.	.	237	.	.	-4	.	.	0.6	.
Northeastern Lake Superior	02B	239	20	37,267	241	12	37,274	2	-8	6	0.6	0[s]	99.3
Northern Lake Huron	02C	310	1,196	30,144	317	1,116	30,218	6	-80	73	1.0	3.5	95.5
Wanapitei and French, Ontario	02D	117	605	16,166	119	473	16,297	1	-132	131	0.7	2.8	96.5
Eastern Georgian Bay	02E	465	4,021	15,310	556	3,745	15,497	91	-277	186	2.8	18.9	78.3
Eastern Lake Huron	02F	278	10,381	3,981	313	9,970	4,358	35	-411	376	2.1	68.1	29.8
Northern Lake Erie	02G	1171	17,061	4,100	1481	16,565	4,286	310	-496	186	6.6	74.2	19.2
Lake Ontario and Niagara Peninsula	02H	2487	9,665	15,078	3114	8,819	15,296	627	-846	218	11.4	32.4	56.2
Upper Ottawa	02J	132	1,892	43,472	134	1,796	43,565	3	-96	94	0.3	3.9	95.8
Central Ottawa	02K	311	3,530	33,605	335	3,137	33,973	25	-394	369	0.9	8.4	90.7
Lower Ottawa	02L	717	6,435	43,502	798	5,986	43,871	80	-449	369	1.6	11.8	86.6
Upper St. Lawrence	02M	226	2,329	2,377	268	2,258	2,405	42	-70	29	5.4	45.8	48.8
Saint-Maurice	02N	83	81	37,969	94	111	37,928	11	30	-41	0.2	0.3	99.5
Central St. Lawrence	02O	2300	14,546	16,909	2612	14,023	17,120	311	-523	211	7.7	41.5	50.7
Lower St. Lawrence	02P	838	8,230	27,318	913	8,421	27,053	75	191	-265	2.5	23.1	74.3
Northern Gaspé Peninsula	02Q	123	1,863	11,115	135	1,809	11,158	11	-54	43	1.0	13.8	85.2
Saguenay	02R	.	1,884	.	.	2,003	.	.	119	.	.	2.5	.
Betsiamites, coast	02S	24	56	24,789	26	59	24,785	2	3	-4	0.1	0.2	99.7
Manicouagan and aux Outardes	02T	.	1	.	.	55	.	.	55	.	.	0.1	.
Moisie and St. Lawrence Estuary	02U	.	0[s]	.	.	8	.	.	7	.	.	0[s]	.
Gulf of St. Lawrence, Romaine	02V	.	0	.	.	16	.	.	16	.	.	0[s]	.
Gulf of St. Lawrence, Natashquan	02W	.	5	.	.	12	.	.	6	.	.	0[s]	.
Petit Mécatina and Strait of Belle Isle	02X	.	0	.	.	0	.	.	0	.	.	0.0	.
Northern Newfoundland	02Y	.	132	.	.	115	.	.	-17	.	.	0.2	.
Southern Newfoundland	02Z	.	270	.	.	193	.	.	-77	.	.	0.4	.
Nottaway, coast	03A	.	135	.	.	123	.	.	-12	.	.	0.2	.
Broadback and Rupert	03B	.	0	.	.	0	.	.	0	.	.	0.0	.
Eastmain	03C	.	0	.	.	0	.	.	0	.	.	0.0	.
La Grande, coast	03D	.	0	.	.	0	.	.	0	.	.	0.0	.
Grande rivière de la Baleine, coast	03E	.	0	.	.	0	.	.	0	.	.	0.0	.
Eastern Hudson Bay	03F	.	0	.	.	0	.	.	0	.	.	0.0	.
Northeastern Hudson Bay	03G	.	0	.	.	0	.	.	0	.	.	0.0	.
Western Ungava Bay	03H	.	0	.	.	0	.	.	0	.	.	0.0	.
Aux Feuilles, coast	03J	.	0	.	.	0	.	.	0	.	.	0.0	.
Koksoak	03K	.	0	.	.	0	.	.	0	.	.	0.0	.
Caniapiscau	03L	.	0	.	.	0	.	.	0	.	.	0.0	.
Eastern Ungava Bay	03M	.	0	.	.	0	.	.	0	.	.	0.0	.
Northern Labrador	03N	.	0	.	.	0	.	.	0	.	.	0.0	.
Churchill, Newfoundland and Labrador	03O	.	5	.	.	1	.	.	-5	.	.	0[s]	.
Central Labrador	03P	.	0	.	.	0	.	.	0	.	.	0.0	.
Southern Labrador	03Q	.	0	.	.	0	.	.	0	.	.	0.0	.
Hayes, Manitoba	04A	.	0	.	.	0	.	.	0	.	.	0.0	.
Southwestern Hudson Bay	04B	.	0	.	.	0	.	.	0	.	.	0.0	.
Severn	04C	.	0	.	.	0	.	.	0	.	.	0.0	.

See notes at the end of the table.

Table 2 – continued

Landscape type by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]
		2001[4]			2011			Change 2001 to 2011[4]			2011		
	code	square kilometres									percent of total area[5]		
Winisk, coast	04D	.	0	.	.	0	.	.	0	.	.	0.0	.
Ekwan, coast	04E	.	0	.	.	0	.	.	0	.	.	0.0	.
Attawapiskat, coast	04F	.	0	.	.	0	.	.	0	.	.	0.0	.
Upper Albany	04G	.	0	.	.	0	.	.	0	.	.	0.0	.
Lower Albany, coast	04H	.	0	.	.	0	.	.	0	.	.	0.0	.
Kenogami	04J	.	0	.	.	0	.	.	0	.	.	0.0	.
Moose, Ontario	04K	.	0	.	.	0	.	.	0	.	.	0.0	.
Missinaibi and Mattagami	04L	.	123	.	.	45	.	.	-78	.	.	0.1	.
Abitibi	04M	121	869	26,306	124	870	26,302	3	1	-4	0.5	3.2	96.4
Harricanaw, coast	04N	.	341	.	.	340	.	.	-2	.	.	0.8	.
Upper South Saskatchewan	05A	309	37,897	7,412	410	39,365	5,842	102	1,468	-1,570	0.9	86.3	12.8
Bow	05B	619	14,816	9,579	819	14,236	9,958	201	-580	379	3.3	56.9	39.8
Red Deer	05C	388	42,706	6,011	458	41,376	7,271	70	-1,330	1,260	0.9	84.3	14.8
Upper North Saskatchewan	05D	301	6,174	21,086	391	5,868	21,303	90	-306	216	1.4	21.3	77.3
Central North Saskatchewan	05E	821	34,652	4,885	1019	33,066	6,273	198	-1,585	1,387	2.5	81.9	15.5
Battle	05F	263	27,380	1,828	301	26,536	2,634	38	-844	806	1.0	90.0	8.9
Lower North Saskatchewan	05G	292	41,669	5,853	310	39,776	7,728	18	-1,893	1,875	0.6	83.2	16.2
Lower South Saskatchewan	05H	350	51,050	2,310	407	48,726	4,577	57	-2,324	2,267	0.8	90.7	8.5
Qu'Appelle	05J	471	67,962	4,446	548	64,212	8,120	76	-3,750	3,674	0.8	88.1	11.1
Saskatchewan	05K	.	13,873	.	.	13,272	.	.	-602	.	.	19.5	.
Lake Winnipegosis and Lake Manitoba	05L	648	31,162	35,988	656	29,927	37,215	8	-1,235	1,227	1.0	44.1	54.9
Assiniboine	05M	759	41,085	7,715	815	38,370	10,373	56	-2,714	2,658	1.6	77.4	20.9
Souris	05N	402	35,884	2,357	416	34,564	3,662	14	-1,319	1,305	1.1	89.4	9.5
Red	05O	1050	19,841	4,202	1101	18,890	5,102	50	-950	900	4.4	75.3	20.3
Winnipeg	05P	512	1,465	42,598	519	1,392	42,664	7	-73	66	1.2	3.1	95.7
English	05Q	435	163	42,323	437	107	42,377	2	-55	54	1.0	0.3	98.7
Eastern Lake Winnipeg	05R	.	0	.	.	0	.	.	0	.	.	0.0	.
Western Lake Winnipeg	05S	.	4,381	.	.	4,052	.	.	-329	.	.	16.8	.
Grass and Burntwood	05T	.	0	.	.	0	.	.	0	.	.	0.0	.
Nelson	05U	.	0	.	.	0	.	.	0	.	.	0.0	.
Beaver, Alberta and Saskatchewan	06A	162	12,495	32,770	168	11,814	33,444	7	-681	675	0.4	26.0	73.6
Upper Churchill, Manitoba	06B	.	0	.	.	4	.	.	4	.	.	0[s]	.
Central Churchill, upper, Manitoba	06C	.	0	.	.	5	.	.	5	.	.	0[s]	.
Reindeer	06D	.	0	.	.	0	.	.	0	.	.	0.0	.
Central Churchill, lower, Manitoba	06E	.	236	.	.	0	.	.	-236	.	.	0.0	.
Lower Churchill, Manitoba	06F	.	0	.	.	0	.	.	0	.	.	0.0	.
Seal, coast	06G	.	0	.	.	0	.	.	0	.	.	0.0	.
Western Hudson Bay, Southern	06H	.	0	.	.	0	.	.	0	.	.	0.0	.
Thelon	06J	.	0	.	.	0	.	.	0	.	.	0.0	.
Dubawnt	06K	.	0	.	.	0	.	.	0	.	.	0.0	.
Kazan	06L	.	0	.	.	0	.	.	0	.	.	0.0	.
Chesterfield Inlet	06M	.	0	.	.	0	.	.	0	.	.	0.0	.
Western Hudson Bay, central	06N	.	0	.	.	0	.	.	0	.	.	0.0	.
Western Hudson Bay, northern	06O	.	0	.	.	0	.	.	0	.	.	0.0	.
Hudson Bay, Southampton Island	06P	.	0	.	.	0	.	.	0	.	.	0.0	.
Foxe Basin, Southampton Island	06Q	.	0	.	.	0	.	.	0	.	.	0.0	.
Foxe Basin, Melville Peninsula	06R	.	0	.	.	0	.	.	0	.	.	0.0	.
Foxe Basin, Baffin Island	06S	.	0	.	.	0	.	.	0	.	.	0.0	.
Hudson Strait, Baffin and Southampton Islands	06T	.	0	.	.	0	.	.	0	.	.	0.0	.
Upper Athabasca	07A	118	1,571	32,843	126	1,431	32,975	8	-140	132	0.4	4.1	95.5
Central Athabasca, upper	07B	134	10,839	27,573	154	10,189	28,203	20	-650	630	0.4	26.4	73.2
Central Athabasca, lower	07C	.	2,311	.	.	2,142	.	.	-169	.	.	4.0	.

See notes at the end of the table.

Table 2 – continued

Landscape type by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]	Settled area[1]	Agricultural land area[2]	Natural and naturalizing area[3]
		2001[4]			2011			Change 2001 to 2011[4]			2011		
	code	square kilometres									percent of total area[5]		
Lower Athabasca	07D	.	0	.	.	0	.	.	0	.	.	0.0	.
Williston Lake	07E	.	25	.	.	39	.	.	13	.	.	0.1	.
Upper Peace	07F	154	17,593	49,598	161	16,329	50,855	7	-1,265	1,258	0.2	24.2	75.5
Smoky	07G	126	11,231	39,608	139	10,749	40,077	13	-482	469	0.3	21.1	78.6
Central Peace, upper	07H	34	4,459	30,249	36	4,183	30,521	3	-275	273	0.1	12.0	87.9
Central Peace, lower	07J	.	1,809	.	.	2,076	.	.	266	.	.	3.6	.
Lower Peace	07K	.	0	.	.	0	.	.	0	.	.	0.0	.
Fond-du-Lac	07L	.	0	.	.	0	.	.	0	.	.	0.0	.
Lake Athabasca, shores	07M	.	0	.	.	0	.	.	0	.	.	0.0	.
Slave	07N	.	0	.	.	0	.	.	0	.	.	0.0	.
Hay	07O	.	0	.	.	0	.	.	0	.	.	0.0	.
Southern Great Slave Lake	07P	.	0	.	.	0	.	.	0	.	.	0.0	.
Great Slave Lake, east arm, south shore	07Q	.	0	.	.	0	.	.	0	.	.	0.0	.
Lockhart	07R	.	0	.	.	0	.	.	0	.	.	0.0	.
Northeastern Great Slave Lake	07S	.	0	.	.	0	.	.	0	.	.	0.0	.
Marian	07T	.	0	.	.	0	.	.	0	.	.	0.0	.
Western Great Slave Lake	07U	.	0	.	.	0	.	.	0	.	.	0.0	.
Alsek	08A	.	0	.	.	0	.	.	0	.	.	0.0	.
Northern coastal waters, British Columbia	08B	.	0	.	.	0	.	.	0	.	.	0.0	.
Stikine, coast	08C	.	0	.	.	0	.	.	0	.	.	0.0	.
Nass, coast	08D	.	0	.	.	0	.	.	0	.	.	0.0	.
Skeena, coast	08E	.	881	.	.	752	.	.	-129	.	.	1.4	.
Central coastal waters, British Columbia	08F	.	167	.	.	85	.	.	-82	.	.	0.2	.
Southern coastal waters, British Columbia	08G	.	103	.	.	114	.	.	11	.	.	0.3	.
Vancouver Island	08H	.	617	.	.	503	.	.	-114	.	.	1.5	.
Nechako	08J	.	2,081	.	.	2,064	.	.	-17	.	.	4.8	.
Upper Fraser	08K	144	2,086	63,348	144	2,014	63,421	0 s	-73	73	0.2	3.1	96.7
Thompson	08L	258	4,638	49,137	277	5,612	48,145	19	973	-992	0.5	10.4	89.1
Lower Fraser	08M	1018	3,354	55,918	1175	3,343	55,772	157	-10	-146	1.9	5.5	92.5
Columbia	08N	579	3,345	96,157	642	3,189	96,251	62	-156	93	0.6	3.2	96.2
Queen Charlotte Islands	08O	.	60	.	.	5	.	.	-55	.	.	0.1	.
Skagit	08P	1	16	1,003	1	4	1,015	0	-12	12	0.1	0.4	99.5
Headwaters Yukon	09A	.	23	.	.	0	.	.	-23	.	.	0.0	.
Pelly	09B	.	0	.	.	0	.	.	0	.	.	0.0	.
Upper Yukon	09C	.	0	.	.	0	.	.	0	.	.	0.0	.
Stewart	09D	.	0	.	.	0	.	.	0	.	.	0.0	.
Central Yukon	09E	.	0	.	.	0	.	.	0	.	.	0.0	.
Porcupine	09F	.	0	.	.	0	.	.	0	.	.	0.0	.
Tanana	09H	.	0	.	.	0	.	.	0	.	.	0.0	.
Copper	09M	.	0	.	.	0	.	.	0	.	.	0.0	.
Upper Liard	10A	.	0	.	.	0	.	.	0	.	.	0.0	.
Central Liard	10B	.	0	.	.	8	.	.	8	.	.	0 s	.
Fort Nelson	10C	.	111	.	.	137	.	.	25	.	.	0.3	.
Central Liard and Petitot	10D	.	0	.	.	0	.	.	0	.	.	0.0	.
Lower Liard	10E	.	0	.	.	0	.	.	0	.	.	0.0	.
Upper Mackenzie, Mills Lake	10F	.	0	.	.	0	.	.	0	.	.	0.0	.
Upper Mackenzie, Camsell Bend	10G	.	0	.	.	0	.	.	0	.	.	0.0	.
Central Mackenzie, Blackwater Lake	10H	.	0	.	.	0	.	.	0	.	.	0.0	.
Great Bear	10J	.	0	.	.	0	.	.	0	.	.	0.0	.
Central Mackenzie, The Ramparts	10K	.	0	.	.	0	.	.	0	.	.	0.0	.
Lower Mackenzie	10L	.	0	.	.	0	.	.	0	.	.	0.0	.
Peel and Southwestern Beaufort Sea	10M	.	0	.	.	0	.	.	0	.	.	0.0	.

See notes at the end of the table.

Table 2 – continued

Landscape type by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Settled area [1]	Agricultural land area [2]	Natural and naturalizing area [3]	Settled area [1]	Agricultural land area [2]	Natural and naturalizing area [3]	Settled area [1]	Agricultural land area [2]	Natural and naturalizing area [3]	Settled area [1]	Agricultural land area [2]	Natural and naturalizing area [3]
		2001 [4]			2011			Change 2001 to 2011 [4]			2011		
	code	square kilometres									percent of total area [5]		
Southern Beaufort Sea	10N	.	0	.	.	0	.	.	0	.	.	0.0	.
Amundsen Gulf	10O	.	0	.	.	0	.	.	0	.	.	0.0	.
Coppermine	10P	.	0	.	.	0	.	.	0	.	.	0.0	.
Coronation Gulf and Queen Maud Gulf	10Q	.	0	.	.	0	.	.	0	.	.	0.0	.
Back	10R	.	0	.	.	0	.	.	0	.	.	0.0	.
Gulf of Boothia	10S	.	0	.	.	0	.	.	0	.	.	0.0	.
Southern Arctic Islands	10T	.	0	.	.	0	.	.	0	.	.	0.0	.
Baffin Island, Arctic drainage	10U	.	0	.	.	0	.	.	0	.	.	0.0	.
Northern Arctic Islands	10V	.	0	.	.	0	.	.	0	.	.	0.0	.
Missouri	11A	55	24,363	2,273	58	23,007	3,627	3	-1,357	1,354	0.2	86.2	13.6

1. Settled area is based on Agriculture and Agri-Food Canada's (AAFC) 30 m land cover code for developed areas. Geographic coverage of this data is presented in Map 1, Appendix C. The following SDAs were only partially covered by AAFC's land cover: Upper Peace-07F (99% coverage), Northeastern Lake Superior-02B (99% coverage), Central Peace, upper-07H (96% coverage), Beaver, Alberta and Saskatchewan-06A (95% coverage), English-05Q (88% coverage), Lake Winnipegosis and Lake Manitoba-05L (88% coverage), Upper Fraser-08K (85% coverage), Lower Fraser-08M (83% coverage), Abitibi-04M (83% coverage), Saint-Maurice-02N (82% coverage) and Betsiamites, coast-02S (80% coverage). Of the above 11 SDAs, no significant settled area was identified in the area outside AAFC's coverage.
2. Agricultural land area is based on the Census of Agriculture variable total farm area.
3. Natural and naturalizing area is based on the residual landscape of a sub-drainage area that is not settled or used for agriculture. The sum of settled area, agricultural land area and natural and naturalizing area may not add up to the total sub-drainage area indicated in Table 1, Appendix C due to rounding. It excludes bodies of water based on the Canada Centre for Remote Sensing (CCRS) land cover time series code 24 (open water). Geographic coverage of this data is presented in Map 1, Appendix C.
4. Data presented for Settled area is for 2000; Change for Settled area is from 2000 to 2011.
5. Total area of the sub-drainage area excluding bodies of water, based on the CCRS land cover time series code 24 (open water) (Table 1, Appendix C).

Note(s): Measuring land cover categories is subject to certain limitations due to difficulties in distinguishing between different land cover types.

Source(s): Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Agriculture and Agri-Food Canada, 2009, *Land Cover for Agricultural Regions of Canada (circa 2000)*, version 12, *http://data.gc.ca/data/en/dataset/f5ded3b0-a5b4-4599-95d6-d853a825792b* (accessed October 9, 2012). Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2001 and 2011. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Table 3
Landscape analysis by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Natural land parcel size [1]	Average distance to natural land parcel [2]		Barrier density [3]
		2011	2001	2011	2011
	code	square kilometres	metres		metres per square kilometre
Saint John and Southern Bay of Fundy, New Brunswick	01A	57.0	15	14	823
Gulf of St. Lawrence and Northern Bay of Fundy, New Brunswick	01B	88.6	6	6	673
Prince Edward Island	01C	2.3	236	229	1,374
Bay of Fundy and Gulf of St. Lawrence, Nova Scotia	01D	19.9	28	26	1,201
Southeastern Atlantic Ocean, Nova Scotia	01E	39.8	4	4	858
Cape Breton Island	01F	38.0	6	6	911
Northwestern Lake Superior	02A	104.2	1	1	296
Northeastern Lake Superior	02B	213.1	0 s	0 s	213
Northern Lake Huron	02C	57.1	3	3	443
Wanapitei and French, Ontario	02D	61.7	3	3	469
Eastern Georgian Bay	02E	6.3	85	86	1,191
Eastern Lake Huron	02F	0.8	392	404	1,258
Northern Lake Erie	02G	0.3	574	580	1,812
Lake Ontario and Niagara Peninsula	02H	2.7	244	247	2,172
Upper Ottawa	02J	39.9	9	9	378
Central Ottawa	02K	23.7	22	22	669
Lower Ottawa	02L	12.7	56	56	844
Upper St. Lawrence	02M	1.9	265	264	1,856
Saint-Maurice	02N	95.6	1	1	335
Central St. Lawrence	02O	4.3	243	245	1,805
Lower St. Lawrence	02P	10.4	70	70	1,105
Northern Gaspé Peninsula	02Q	19.5	30	30	913
Saguenay	02R	102.0	8	8	193
Betsiamites, coast	02S	152.4	0 s	0 s	155
Manicouagan and aux Outardes	02T	150.4	0 s	0 s	42
Moisie and St. Lawrence Estuary	02U	290.4	0 s	0 s	105
Gulf of St. Lawrence, Romaine	02V	237.1	0	0	16
Gulf of St. Lawrence, Natashquan	02W	96.6	0 s	0 s	26
Petit Mécatina and Strait of Belle Isle	02X	99.2	0 s	0 s	8
Northern Newfoundland	02Y	102.2	0 s	0 s	301
Southern Newfoundland	02Z	71.1	1	1	293
Nottaway, coast	03A	155.2	0 s	0 s	144
Broadback and Rupert	03B	65.3	0 s	0 s	26
Eastmain	03C	43.1	0 s	0 s	9
La Grande, coast	03D	27.4	0 s	0 s	24
Grande rivière de la Baleine, coast	03E	37.7	0 s	0 s	3
Eastern Hudson Bay	03F	26.5	0	0	0 s
Northeastern Hudson Bay	03G	25.8	0	0	0 s
Western Ungava Bay	03H	48.4	0	0	2
Aux Feuilles, coast	03J	39.4	0	0	0 s
Koksoak	03K	108.9	0	0	1
Caniapiscau	03L	42.0	0 s	0 s	2
Eastern Ungava Bay	03M	72.4	0 s	0 s	0 s
Northern Labrador	03N	60.3	0 s	0 s	1
Churchill, Newfoundland and Labrador	03O	44.2	0 s	0 s	35
Central Labrador	03P	210.1	0 s	0 s	15
Southern Labrador	03Q	102.7	0 s	0 s	19
Hayes, Manitoba	04A	130.0	0	0	11
Southwestern Hudson Bay	04B	1,259.7	0 s	0 s	1
Severn	04C	153.3	0 s	0 s	3
Winisk, coast	04D	143.7	0 s	0 s	6
Ekwan, coast	04E	822.1	0 s	0 s	0
Attawapiskat, coast	04F	295.3	0 s	0 s	12
Upper Albany	04G	71.5	0 s	0 s	19
Lower Albany, coast	04H	678.6	0 s	0 s	3
Kenogami	04J	386.2	0 s	0 s	98
Moose, Ontario	04K	254.2	0 s	0 s	17

See notes at the end of the table.

Table 3 – continued

Landscape analysis by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Natural land parcel size [1]	Average distance to natural land parcel [2]		Barrier density [3]
		2011	2001	2011	2011
	code	square kilometres	metres		metres per square kilometre
Missinaibi and Mattagami	04L	489.3	0 s	0 s	182
Abitibi	04M	56.5	9	9	285
Harricanaw, coast	04N	239.1	2	2	146
Upper South Saskatchewan	05A	2.2	579	595	739
Bow	05B	3.8	305	324	837
Red Deer	05C	1.3	539	566	782
Upper North Saskatchewan	05D	7.3	107	107	498
Central North Saskatchewan	05E	0.6	653	650	1,003
Battle	05F	0.3	818	826	952
Lower North Saskatchewan	05G	0.7	758	807	765
Lower South Saskatchewan	05H	0.8	1,038	1,102	890
Qu'Appelle	05J	0.5	1,259	1,295	932
Saskatchewan	05K	12.3	246	234	286
Lake Winnipegosis and Lake Manitoba	05L	3.5	213	209	519
Assiniboine	05M	0.7	500	500	946
Souris	05N	0.6	1,060	1,062	913
Red	05O	0.6	465	476	1,246
Winnipeg	05P	20.1	7	7	254
English	05Q	40.4	0 s	0 s	197
Eastern Lake Winnipeg	05R	101.4	0 s	0 s	28
Western Lake Winnipeg	05S	9.0	72	72	368
Grass and Burntwood	05T	106.7	0 s	0 s	67
Nelson	05U	78.9	0 s	0 s	58
Beaver, Alberta and Saskatchewan	06A	8.6	89	87	284
Upper Churchill, Manitoba	06B	114.0	0 s	0 s	35
Central Churchill, upper, Manitoba	06C	48.7	0 s	0 s	48
Reindeer	06D	20.3	0	0	10
Central Churchill, lower, Manitoba	06E	35.6	0	0	34
Lower Churchill, Manitoba	06F	109.7	0	0	13
Seal, coast	06G	57.5	0	0	0
Western Hudson Bay, Southern	06H	29.6	0	0	0 s
Thelon	06J	45.6	0	0	0 s
Dubawnt	06K	18.2	0	0	0
Kazan	06L	26.5	0	0	0 s
Chesterfield Inlet	06M	49.0	0 s	0 s	1
Western Hudson Bay, central	06N	19.4	0 s	0 s	2
Western Hudson Bay, northern	06O	57.1	0	0	0
Hudson Bay, Southampton Island	06P	20.4	0 s	0 s	1
Foxe Basin, Southampton Island	06Q	45.5	0	0	0
Foxe Basin, Melville Peninsula	06R	69.7	0 s	0 s	1
Foxe Basin, Baffin Island	06S	31.2	0	0	1
Hudson Strait, Baffin and Southampton Islands	06T	23.9	0 s	0 s	0 s
Upper Athabasca	07A	94.6	7	7	243
Central Athabasca, upper	07B	6.6	122	121	453
Central Athabasca, lower	07C	48.9	13	13	123
Lower Athabasca	07D	174.7	0 s	0 s	34
Williston Lake	07E	1,581.4	0 s	0 s	29
Upper Peace	07F	10.1	86	87	234
Smoky	07G	11.0	98	99	319
Central Peace, upper	07H	22.0	34	34	137
Central Peace, lower	07J	77.2	9	9	76
Lower Peace	07K	173.0	0	0	15
Fond-du-Lac	07L	22.5	0	0 s	2
Lake Athabasca, shores	07M	46.8	0 s	0 s	7
Slave	07N	104.0	0 s	0 s	60
Hay	07O	549.9	0 s	0 s	47
Southern Great Slave Lake	07P	332.7	0 s	0 s	56
Great Slave Lake, east arm, south shore	07Q	29.1	0	0	3
Lockhart	07R	19.5	0	0	1

See notes at the end of the table.

Table 3 – continued

Landscape analysis by sub-drainage area, 2001 and 2011

	Sub-drainage area code	Natural land parcel size [1]	Average distance to natural land parcel [2]		Barrier density [3]
		2011	2001	2011	2011
	code	square kilometres	metres		metres per square kilometre
Northeastern Great Slave Lake	07S	31.7	0 s	0 s	21
Marian	07T	38.1	0	0	6
Western Great Slave Lake	07U	118.0	0	0 s	30
Alsek	08A	647.8	0 s	0 s	34
Northern coastal waters, British Columbia	08B	1,180.8	0 s	0 s	7
Stikine, coast	08C	615.8	0 s	0 s	16
Nass, coast	08D	327.8	0 s	0 s	43
Skeena, coast	08E	517.3	0 s	0 s	140
Central coastal waters, British Columbia	08F	96.9	0 s	0 s	40
Southern coastal waters, British Columbia	08G	183.3	2	2	193
Vancouver Island	08H	93.7	4	4	683
Nechako	08J	248.0	2	2	214
Upper Fraser	08K	734.5	1	1	253
Thompson	08L	381.0	2	2	552
Lower Fraser	08M	80.6	10	10	483
Columbia	08N	390.6	2	2	409
Queen Charlotte Islands	08O	83.4	0 s	0 s	178
Skagit	08P	1,015.0	0	0	168
Headwaters Yukon	09A	775.1	0 s	0 s	50
Pelly	09B	1,204.8	0 s	0 s	32
Upper Yukon	09C	399.7	0 s	0 s	33
Stewart	09D	1,149.0	0 s	0 s	29
Central Yukon	09E	220.1	0 s	0 s	60
Porcupine	09F	372.8	0	0 s	44
Tanana	09H	1,452.6	0	0	23
Copper	09M	4,107.5	0	0	0
Upper Liard	10A	1,083.2	0 s	0 s	30
Central Liard	10B	1,079.8	0 s	0	14
Fort Nelson	10C	3,883.3	0 s	0 s	24
Central Liard and Petitot	10D	553.8	0	0	15
Lower Liard	10E	702.0	0 s	0 s	14
Upper Mackenzie, Mills Lake	10F	454.0	0 s	0 s	20
Upper Mackenzie, Camsell Bend	10G	388.1	0 s	0 s	8
Central Mackenzie, Blackwater Lake	10H	834.0	0	0	18
Great Bear	10J	91.1	0 s	0 s	12
Central Mackenzie, The Ramparts	10K	479.1	0 s	0 s	22
Lower Mackenzie	10L	75.4	0 s	0 s	21
Peel and Southwestern Beaufort Sea	10M	64.6	0 s	0 s	17
Southern Beaufort Sea	10N	62.8	0	0	16
Amundsen Gulf	10O	193.5	0 s	0 s	3
Coppermine	10P	37.8	0 s	0 s	3
Coronation Gulf and Queen Maud Gulf	10Q	50.7	0	0	0 s
Back	10R	59.8	0	0	0 s
Gulf of Boothia	10S	68.9	0 s	0 s	1
Southern Arctic Islands	10T	78.2	0 s	0 s	1
Baffin Island, Arctic drainage	10U	83.0	0 s	0 s	1
Northern Arctic Islands	10V	632.4	0 s	0 s	1
Missouri	11A	3.4	390	366	575

1. Natural land parcel size refers to the size of continuous natural and/or naturalizing land areas including forests, wetlands, barrenlands, grasslands and shrublands, measured in km^2.
2. Average distance to natural land parcel is defined as the average distance from any location within a sub-drainage area to a natural land parcel.
3. Barrier density refers to the density of roads, rail lines and electrical transmission lines, measured in m of barriers/km^2 of land, but excludes other types of infrastructure such as pipelines.

Note(s): Total area of the sub-drainage area excluding bodies of water, based on the Canada Centre for Remote Sensing (CCRS) land cover time series code 24 (open water) (Table 1, Appendix C).

Source(s): Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Statistics Canada, 2011, *Road Network File, 2011*, Catalogue no. 92-500-X. Natural Resources Canada, 2012, *CanVec*, Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, *www.geogratis.gc.ca* (accessed March 1, 2012). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Appendix D

Ecosystem services potential: Boreal forest case study methodology

The boreal forest case study is a proof-of-concept research and development activity conducted by Environment Canada and Natural Resources Canada as part of the MEGS initiative. This issue of *Human Activity and the Environment* includes results for a single ecosystem service—water purification—that was included in a larger study on the potential to provide 10 services across Canadian boreal forest. This study is undergoing further review and validation.

Ecosystem services included in the case study were selected based on their relevance to broad-scale assessment, federal policy, and the study scope, the importance of the service, and the likelihood of success in spatially mapping the indicator.

The ecosystem potential analyses included the identification of the key service-specific biophysical processes and drivers, their relationships with the targeted ecosystem services, and the development of quantitative models to provide coarse estimation of ecosystem potential for each selected service. The models incorporate biophysical data, such as climatic variables, topography, landscape structure and configuration as well as land cover data. This approach complements the human landscape modification analysis in section 3.2, which covers a broader geographic area, but only uses land cover and land use variables to coarsely evaluate overall ecosystem integrity.

For each individual service, the case study sought out the best available model to assess potential from published and peer reviewed literature and expert opinion. The best available model was selected and modified based primarily on the performance of biophysical models, their ecological relevance in the boreal, the availability of reliable spatially explicit data to reflect the key biophysical process represented in the model and the sensitivity to changes in management decisions.

The spatial extent of this case study was watersheds that fall almost entirely within the Canadian boreal forest region. The watershed was used as the unit of analysis. This selection was based on the fact that watershed delineations are ecologically meaningful and relevant for decision-making and that this spatial resolution was suitable for ensuring both data availability and feasibility of data processing.

For the integrated assessment of the overall spatial variability of service delivery, the project used flower diagrams which allow for the representation of the magnitude of delivery of multiple ecosystem services, without masking the individual contribution of each to the overall service potential.

Water purification: methods, data sources and calculations

The objective of this part of the study was to estimate water purification potential across Canadian boreal forest watersheds based on landscape conditions and related environmental quality indicators.

The methodology selected is consistent with and builds on an analysis conducted across the continental United States by the US Forest Service.[1,2] The extent of analysis corresponds to all watersheds that fall completely within Canada's boreal zone.[3]

1. Weidner, E. and A. Todd, 2011, *From the Forest to the Faucet: Drinking Water and Forests in the US*, Methods Paper, United States Department of Agriculture Forest Service, *www.fs.fed.us/ecosystemservices/pdf/forests2faucets/F2F_Methods_Final.pdf* (accessed April 15, 2013).
2. Barnes, M.C., A.H. Todd, R. Whitney Lija and P.K. Barten, 2009, *Forests, Water and People: Drinking water supply and forest lands in the Northeast and Midwest United States*, United States Department of Agriculture Forest Service, *http://na.fs.fed.us/pubs/misc/watersupply/forests_water_people_watersupply.pdf* (accessed April 15, 2013).
3. Brandt, J.P., 2009, "The extent of the North American boreal zone," *Environmental Reviews,* Vol. 17, pages 101 to161.

The selected predictor variables used to assess the water purification potential index, additional information on the datasets used and associated data sources, as well as the scoring scheme associated with ranges of values within the distribution of observed values by attribute, are provided in Tables 1 and 2 (Appendix D).

Table 1
Selected attributes, datasets, calculations and sources

ID	Attribute	Datasets	Calculations	Sources
1	Percent forested land by watershed (F)	Canada 250m Land Cover Time Series 2000-2011	Total area of forest classes was calculated by watershed using these four NRCan CCRS classes: 'needleleaf_temperate,' 'needleleaf_taiga,' 'broadleaf,' and 'mixed_forest'.	Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing (CCRS).
2	Percent agricultural land by watershed (A)	Canada 250m Land Cover Time Series 2000-2011	Total area was calculated by watershed using the NRCan CCRS 'cropland' land cover class.	Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing.
3	Weighted percent riparian forest cover (R)	Canada 250m Land Cover Time Series 2000-2011; Waterbody Edge Density	Calculated as the ratio between the total area of forest classes within a 250 m buffer along water bodies in a watershed and the total edge of waterbodies.	Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011*, Earth Sciences Sector, Canada Centre for Remote Sensing. Natural Resources Canada, 2007, *National Hydro Network, Canada,* Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, *http://geobase.ca/geobase/en /data/nhn/index.html* (accessed March 1, 2013).
4	Percent wetlands (W)	CanVec	Estimated as the total wetlands area summed by watershed.	Natural Resources Canada, 2013, *CanVec,* Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, *www.geogratis.gc.ca* (accessed September 12, 2013).
5	Percent total anthropogenic disturbance (TD)	EC Boreal disturbance dataset 2010	Estimated as the total area disturbed by polygonal (Cutblock; Mine; Reservoir; Settlement; Well site; Agriculture; Oil and Gas; Unknown) and buffered linear (road; powerline; railway; seismic line; pipeline; dam; airstrip; unknown) anthropogenic features. This attribute could only be estimated for 2010 due to data availability.	Pasher, J., E. Seed, and J. Duffe, 2013, "Development of boreal ecosystem anthropogenic disturbance layers for Canada based on 2008 to 2010 Landsat imagery," *Canadian Journal of Remote Sensing,* Vol. 39, no. 1, pages 42 to 58.
6	Weighted percent burn area (B)	Canadian National Fire Database; Homogeneous Fire Regimes	Estimated by associating each watershed with the Homogeneous Fire Regime zones (HFR) in which the largest proportion of the watershed was located. For example, if 30%, 60%, and 30% of a watershed was located in HFR 1, 24, 21 respectively, then HFR 24 was the de facto HFR for that watershed. For each HFR zone, natural range of variability in decadal burn e xtent was assessed using data from 1940 to 2010. The post-fire regeneration time for vegetation to resume its hydrologic functions was set at 10 years. For example, total area burn forthe year 2000 was estimated by including fires reported between 1990 to 1999 inclusively. [1]	Natural Resources Canada, 2010, *Canadian National Fire Database, Agency Fire Data*, Canadian Forest Service, Northern Forestry Centre, http://cwfis.cfs.nrcan.gc.ca/en_CA/nfdb/poly (accessed September 12, 2013). Boulanger. Y., S. Gauthier, P.J. Burton, and M.-A. Vaillancourt, 2012, "An alternative fire regime zonation for Canada," *International Journal of Wildland Fire*, Vol. 21, no. 8, pages 1052 to 1064.
7	Edge density (ED)	EC Boreal disturbance dataset 2010	Estimated as the total edge from linear features (road, powerline, railway, seismic line, pipeline, dam, airstrip, unknown) divided by total watershed area. This attribute could only be estimated for 2010 due to data availability.	Pasher, J., E. Seed, and J. Duffe, 2013, "Development of boreal ecosystem anthropogenic disturbance layers for Canada based on 2008 to 2010 Landsat imagery," *Canadian Journal of Remote Sensing,* Vol. 39, no. 1, pages 42 to 58.

See notes at the end of the table.

Table 1 – continued

Selected attributes, datasets, calculations and sources

ID	Attribute	Datasets	Calculations	Sources
8	Linear Density (LD)	Roads; Powerlines; Pipelines; Railways	Estimated as the total edge from linear features (power corridors, roads, railways). However, the attribute was estimated for 2001 and 2010 to allow change analysis.	Statistics Canada, 2002, *Road Network File, 2001,* Catalogue no. 92F0157X. Statistics Canada, 2006, *Road Network File, 2006*, Catalogue no. 92-500-X. Natural Resources Canada, 2013, *CanVec,* Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, *www.geogratis.gc.ca* (accessed September 12, 2013). Natural Resources Canada, 2012, *National Railway Network (NRWN)*, *www.geobase.ca/geobase/en/data/nrwn/description.html* (accessed February 1, 2013).
9	Human Footprint (HF)	Roads; Powerlines; Pipelines; Railways; Settlements; Agriculture	Estimated as the total area disturbed by settlements and linear anthropogenic features (power corridors, roads, railways) within a 1 km buffer.	Statistics Canada, 2002, *Road Network File, 2001,* Catalogue no. 92F0157X. Statistics Canada, 2006, *Road Network File, 2006*, Catalogue no. 92-500-X. Natural Resources Canada, 2013, *CanVec,* Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information, www.geogratis.gc.ca (accessed September 12, 2013). Natural Resources Canada, 2012, *National Railway Network (NRWN), www.geobase.ca/geobase/en/data/nrwn/description.html* (accessed February 2013). Statistics Canada, 2002, *Population Ecumene Census Division Boundary File (Geography Products: Spatial Information Products, 2001 Census)*, Catalogue no. 92F0159X. Statistics Canada, 2007, *Population Ecumene Census Division Cartographic Boundary File, Census year 2006*, Catalogue no. 92-159-X. Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011,* Earth Sciences Sector, Canada Centre for Remote Sensing.
10	Slope (S)	Canadian Digital Elevation Data (CDED, 1:50,000)	Derived from a digital elevation model (1:250,000) using the bilinear interpolation method of re-sampling and averaged over the watershed.	Natural Resources Canada, 2000, *Canadian Digital Elevation Data,* Earth Sciences Sector, Centre for Topographic Information, *www.geobase.ca/geobase/en/data/cded/index.html* (accessed September 12, 2013).
11	N and S exceedance level (NS)	Aurams model from EC (data for 2000)	Assigned for regions where current atmospheric deposition of N and S is greater than the critical loads ('exceeded'). Critical loads are defined as "a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge." [2]	Environment Canada, 2013, Critical load exceedance data.

1. Boulanger, Y., S. Gauthier, P.J. Burton and M.-A. Vaillancourt, 2012, "An alternative fire regime zonation for Canada," *International Journal of Wildland Fire*, Vol. 21, no. 8, pages 1052 to 1064.
2. Nilsson, J. and P. Grennfelt (eds.), 1988, *Critical Loads for Sulphur and Nitrogen*, Miljörapport1988:15, Nordic Council of Ministers, Copenhagen.

Source(s): Environment Canada and Natural Resources Canada, 2013.

Table 2
Scoring scheme associated with ranges of values within the distribution of observed values by attribute

ID	Attribute	Scoring for watershed average			
		Low (1 point)	Moderate (2 points)	High (3 points)	Very high (4 points)
1	Percent forested land by watershed (F)	0 to 24	25 to 49	50 to 75	> 75
2	Percent agricultural land by watershed (A)	> 30	21 to 30	10 to 20	< 10
3	Percent riparian forest cover (R)	0 to 29	30 to 50	51 to 70	> 70
4	Percent wetlands (W)	0 to 2.68	2.68 to 7.47	7.47 to 21.37	> 21.37
5	Percent total anthropogenic disturbance (D)	> 5	0 to 5	…	0
6	Percent burn area (B), by Homogeneous Fire Regime:				
a)	1	> 2.84	0.47 to 2.84	0.006 to 0.47	0 to 0.006
b)	2	> 0.83	…	0 to 0.83	0
c)	3	> 6.22	1.99 to 6.22	0.70 to 1.99	0 to 0.70
d)	4	> 0.18	…	0 to 0.18	0
e)	5	> 0	…	…	0
f)	6	> 1.89	…	0 to 1.89	0
g)	7	> 1.27	…	0 to 1.27	0
h)	8	> 0	…	…	0
i)	9	> 0	…	…	0
j)	10	> 0.03	…	0 to 0.03	0
k)	11	> 0	…	…	0
l)	12	> 0	…	…	0
m)	13	> 0.06	…	0 to 0.06	0
n)	14	> 1.60	…	0.01 to 1.60	0
o)	15	> 0	…	…	0
p)	16	> 8.80	0.58 to 8.80	0.08 to 0.58	0 to 0.08
q)	17	> 6.20	0.99 to 6.20	0.44 to 0.99	0 to 0.44
r)	18	> 0.10	0.02 to 0.10	0 to 0.02	0
s)	19	> 0.62	…	0 to 0.62	0
t)	20	> 0.29	…	0 to 0.29	0
u)	21	> 4.68	0.84 to 4.68	0.22 to 0.84	0 to 0.22
v)	22	> 0	…	…	0
w)	23	> 0	…	…	0
x)	24	> 4.45	1.36 to 4.45	0.55 to 1.36	0 to 1.36
y)	25	> 0.014	…	0 to 0.014	0
z)	26	> 4.51	1.08 to 4.51	0 to 1.08	0
aa)	27	> 1.73	0.24 to 1.73	0 to 0.24	0
ab)	28	> 4.49	0.32 to 4.49	0.03 to 0.32	0 to 0.03
ac)	29	> 3.92	0.16 to 3.92	0 to 0.16	0
ad)	30	> 0.69	…	0 to 0.69	0
ae)	31	> 4.95	0.99 to 4.95	0.05 to 0.99	0
af)	32	> 5.68	2.05 to 5.68	0.39 to 2.05	0 to 0.39
ag)	33	> 1.68	0.97 to 1.68	0.14 to 0.97	0 to 0.14
7	Edge density (ED)	> 0.27	0.5 to 0.27	0.005 to 0.5	0 to 0.005
8	Linear Density (LD)	> 0.05	> 0.016 to 0.05	0.012 to 0.016	0 to 0.012
9	Human Footprint (HF) 2000	> 7.71	2 to 7.71	0.18 to 2	0 to 0.18
9	Human Footprint (HF) 2010	> 7.27	2.33 to 7.27	0.24 to 2.33	0 to 0.24
10	Slope (S)	> 0.97	0.45 to 0.97	0.22 to 0.45	0 to 0.22
11	N and S exceedance level (NS)	> 0	-74.305 to 0	-161.536 to -74.305	< -161.536

Source(s): Environment Canada and Natural Resources Canada, 2013.

Various partitioning techniques were used to identify the score associated with each potential value of an attribute. When there was sufficient knowledge to support the identification of an ecological threshold for a given attribute as it related to water purification, then such information was used to identify relative weighting scores for the observed range of variability. However, for many ecological phenomena, no clear threshold of response to a selected predictive variable has been observed or reported. The other technique used was to break the distribution in observed values into its respective quartiles.

The Water Purification Potential Index (WaPPI) was calculated for 2000 and 2010 using the above predictor variables as follows:

$$WaPPI = F + A + R + W + B + LD + HF + S + NS$$

where F equals percent forested land by watershed; A equals percent agricultural land by watershed; R equals weighted percent riparian forest cover; W equals percent wetlands; B equals weighted percent burn area; LD equals linear density; HF equals human footprint; S equals slope; and NS equals nitrogen and sulphur exceedance level.

For comparison purposes, WaPPI was also assessed using a different national dataset for total disturbance (TD) and edge density (ED).

Appendix E

Biomass extraction

Biomass extraction represents the amount of organic material produced by or derived from living organisms that humans extract from the environment. Biomass extraction data are provided for various sources (e.g., agricultural crops, livestock and poultry, milk, honey and maple products, forestry, fisheries), but are not a complete representation of all biomass extraction in Canada.

Production data from multiple sources were summed for the various types of biomass to calculate biomass extraction (tonnage weight) (Table 1, Appendix E). Some mathematical adjustments were performed to ensure comparability of results, for example fluids (litres) were converted to tonnage using a conversion factor. Some underestimation may occur as suppressed and unreliable source data were treated as zeros.

Table 1
Biomass extraction data sources

Variable	Source
Agricultural crops	
Principle field crops	Statistics Canada, CANSIM table 001-0010 (accessed February 7, 2013).
Potatoes	Statistics Canada, CANSIM table 001-0014 (accessed February 7, 2013).
Vegetables	Statistics Canada, CANSIM table 001-0013 (accessed February 7, 2013).
Greenhouse vegetables	Statistics Canada, CANSIM table 001-0006 (accessed February 7, 2013).
Fresh and processed fruits	Statistics Canada, CANSIM table 001-0009 (accessed February 7, 2013).
Livestock and poultry	
Poultry	Statistics Canada, CANSIM table 003-0018 (accessed February 7, 2013).
Hogs	Agriculture and Agri-Food Canada, 2012, *009D Average Warm Carcass Weights at Federally Inspected Plants*, *http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=pR&r=135&pdctc=* (accessed May 7, 2013).
Cattle	Statistics Canada, CANSIM table 003-0083 (accessed May 9, 2013). Agriculture and Agri-Food Canada, 2012, *009D Average Warm Carcass Weights at Federally Inspected Plants*, *http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=pR&r=135&pdctc=* (accessed May 7, 2013).
Sheep and lamb	Statistics Canada, CANSIM table 003-0094 (accessed May 9, 2013).
Milk, maple products and honey	
Milk	Statistics Canada, CANSIM table 003-0011 (accessed February 7, 2013). Food and Agriculture Organization of the United Nations (FAO) and the Information Network on Post-harvest Operations (INPhO), 1998, “Chapitre 2 Laits d’animaux laitiers,” *Le lait et les produits laitiers dans la nutrition humaine*, *www.fao.org/docrep/t4280f/T4280F04.htm#Chapitre* (accessed August 14, 2013). Wikipedia, 2013, *Masse volumique*, *http://fr.wikipedia.org/wiki/Masse_volumique* (accessed August 14, 2013).
Maple	Statistics Canada, 2011, *Production and Value of Honey and Maple Products, 2011,* Catalogue no 23-221-X. Agriculture and Agri-Food Canada, 2007, *Canadian Maple Products Situation and Trends 2006-2007*, *http://www5.agr.gc.ca/resources/prod/doc/misb/hort/sit/pdf/maple_2006-07_e.pdf* (accessed August 14, 2013).

Table 1 – continued

Biomass extraction data sources

Variable	Source
Honey	Statistics Canada, 2011, *Production and Value of Honey and Maple Products, 2011,* Catalogue no 23-221-X.
Forestry	
Trees	Natural Resources Canada, 2012, *The State of Canada's Forests: Annual Report 2012*, Catalogue no. Fo1-6/2012E-PDF, *http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/34055.pdf* (accessed February 7, 2013). United Nations Economic Commission for Europe and the Food and Agriculture Organization of the United Nations, 2010, *Forest Product Conversion Factors for the UNECE Region*, Geneva Timber and Forest Discussion Paper 49, *www.unece.org/fileadmin/DAM/timber/publications/DP-49.pdf* (accessed February 7, 2013).
Fisheries	
Freshwater fisheries	Fisheries and Oceans Canada, 2012, *Freshwater Fisheries - Catches and Landed Values by Species, By Province/Territory, 2010*, *www.dfo-mpo.gc.ca/stats/commercial/land-debarq/freshwater-eaudouce/2010-eng.htm* (accessed February 7, 2013).
Aquaculture	Statistics Canada, CANSIM table 003-0001 (accessed February 7, 2013).
Sea fisheries	Fisheries and Oceans Canada, 2012, *Seafisheries, Landings, Commercial Fisheries, http://dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm* (accessed February 5, 2013).

Appendix F

Freshwater wetland ecosystem goods and services tables

Table 1
Variables for the supply of wetland services, southern Canada

	Sub-drainage area code	Area [1]	Extent characteristics	
			Wetland extent [2]	Peatland extent [3]
	code	square kilometres	percent of area	
Saint John and Southern Bay of Fundy	01A	41,987	< 7.5	< 7.5
Gulf of St. Lawrence and Northern Bay of Fundy	01B	60,653	< 7.5	< 7.5
Prince Edward Island	01C	5,943	< 7.5	< 7.5
Bay of Fundy and Gulf of St. Lawrence, Nova Scotia	01D	21,499	7.5 to < 15.0	7.5 to < 15.0
Southeastern Atlantic Ocean, Nova Scotia	01E	23,222	7.5 to < 15.0	7.5 to < 15.0
Cape Breton Island	01F	10,685	7.5 to < 15.0	< 7.5
Northwestern Lake Superior	02A	51,541	7.5 to < 15.0	7.5 to < 15.0
Northeastern Lake Superior	02B	61,283	7.5 to < 15.0	< 7.5
Northern Lake Huron	02C	45,421	7.5 to < 15.0	< 7.5
Wanapitei and French, Ontario	02D	19,669	7.5 to < 15.0	< 7.5
Eastern Georgian Bay	02E	28,778	15.0 to < 25.0	< 7.5
Eastern Lake Huron	02F	33,728	7.5 to < 15.0	< 7.5
Northern Lake Erie	02G	35,302	7.5 to < 15.0	< 7.5
Lake Ontario and Niagara Peninsula	02H	39,336	15.0 to < 25.0	< 7.5
Upper Ottawa	02J	50,670	7.5 to < 15.0	7.5 to < 15.0
Central Ottawa	02K	40,753	7.5 to < 15.0	< 7.5
Lower Ottawa	02L	54,719	7.5 to < 15.0	< 7.5
Upper St. Lawrence	02M	6,139	15.0 to < 25.0	< 7.5
Saint-Maurice	02N	42,251	7.5 to < 15.0	< 7.5
Central St. Lawrence	02O	35,600	7.5 to < 15.0	< 7.5
Lower St. Lawrence	02P	37,780	7.5 to < 15.0	< 7.5
Northern Gaspé Peninsula	02Q	13,383	< 7.5	< 7.5
Saguenay	02R	88,072	7.5 to < 15.0	< 7.5
Betsiamites, coast	02S	27,473	< 7.5	< 7.5
Northern Newfoundland	02Y	66,153	15.0 to < 25.0	15.0 to < 25.0
Southern Newfoundland	02Z	44,441	25.0 to < 35.0	15.0 to < 25.0
Nottaway, coast	03A	67,938	35.0 to < 50.0	15.0 to < 25.0
Kenogami	04J	52,370	≥ 65.0	35.0 to < 50.0
Missinaibi and Mattagami	04L	60,593	35.0 to < 50.0	25.0 to < 35.0
Abitibi	04M	29,291	35.0 to < 50.0	25.0 to < 35.0
Harricanaw, coast	04N	43,509	50.0 to < 65.0	35.0 to < 50.0
Upper South Saskatchewan	05A	46,410	< 7.5	< 7.5
Bow	05B	25,628	< 7.5	< 7.5
Red Deer	05C	50,315	7.5 to < 15.0	< 7.5
Upper North Saskatchewan	05D	27,983	7.5 to < 15.0	< 7.5
Central North Saskatchewan	05E	42,275	7.5 to < 15.0	< 7.5
Battle	05F	30,241	< 7.5	< 7.5
Lower North Saskatchewan	05G	49,652	7.5 to < 15.0	< 7.5
Lower South Saskatchewan	05H	55,268	< 7.5	< 7.5
Qu'Appelle	05J	74,589	< 7.5	< 7.5
Saskatchewan	05K	81,194	50.0 to < 65.0	15.0 to < 25.0
Lake Winnipegosis and Lake Manitoba	05L	82,719	50.0 to < 65.0	7.5 to < 15.0
Assiniboine	05M	51,259	15.0 to < 25.0	< 7.5
Souris	05N	39,591	< 7.5	< 7.5
Red	05O	25,266	7.5 to < 15.0	< 7.5
Winnipeg	05P	55,104	25.0 to < 35.0	15.0 to < 25.0
English	05Q	52,550	25.0 to < 35.0	7.5 to < 15.0
Eastern Lake Winnipeg	05R	63,642	≥ 65.0	25.0 to < 35.0
Western Lake Winnipeg	05S	41,819	≥ 65.0	25.0 to < 35.0
Beaver, Alberta and Saskatchewan	06A	49,940	25.0 to < 35.0	15.0 to < 25.0
Upper Athabasca	07A	34,856	15.0 to < 25.0	< 7.5
Central Athabasca, upper	07B	40,496	35.0 to < 50.0	7.5 to < 15.0
Central Athabasca, lower	07C	57,030	35.0 to < 50.0	25.0 to < 35.0

See notes at the end of the table.

Table 1 – continued

Variables for the supply of wetland services, southern Canada

	Sub-drainage area code	Area [1]	Extent characteristics	
			Wetland extent [2]	Peatland extent [3]
	code	square kilometres	percent of area	
Smoky	07G	51,508	15.0 to < 25.0	< 7.5
Nass, coast	08D	29,036	< 7.5	< 7.5
Skeena, coast	08E	55,751	< 7.5	< 7.5
Central coastal waters, British Columbia	08F	54,658	< 7.5	< 7.5
Southern coastal waters, British Columbia	08G	41,986	< 7.5	< 7.5
Vancouver Island	08H	34,882	< 7.5	< 7.5
Nechako	08J	47,332	< 7.5	< 7.5
Upper Fraser	08K	67,088	< 7.5	< 7.5
Thompson	08L	55,777	< 7.5	< 7.5
Lower Fraser	08M	61,880	< 7.5	< 7.5
Columbia	08N	102,925	< 7.5	< 7.5
Queen Charlotte Islands	08O	10,049	7.5 to < 15.0	7.5 to < 15.0
Skagit	08P	1,027	< 7.5	< 7.5
Missouri	11A	27,097	< 7.5	< 7.5

1. Total area of the sub-drainage area including large bodies of water.
2. Wetland extent was calculated using coefficients derived from Agriculture and Agri-Food Canada 2011 30 m land cover and regional and provincial high resolution wetland datasets.
3. Peatland extent estimates were derived from soil landscape geographies of the national peatland database and area weighted to sub-drainage areas.

Note(s): Tables 1, 2 and 3 (Appendix F) present supply and demand indicators for wetland ecosystem goods and services organized using an accounting approach. Some duplication occurs within the tables.

Source(s): Statistics Canada, CANSIM table 153-0035 (accessed October 8, 2013). Prince Edward Island Department of Environment, Energy and Forestry, 2009, *2009 PEI Wetland Inventory*, *www.gov.pe.ca/gis/index.php3?number=1036522&lang=E* (accessed December 2012). Nova Scotia Department of Natural Resources, 2013, *Forest Inventory – Geographic Information Systems*, *http://novascotia.ca/natr/forestry/gis/dl_forestry.asp* (accessed March 2013). New Brunswick Department of Environment and Local Government, 2013, *Regulated Wetlands*, *www.snb.ca/geonb1/e/DC/RW.asp* (accessed October 2011). Ontario Ministry of Natural Resources, Science and Information Branch, 2008, *Southern Ontario Land Resource Information System (SOLRIS)*. Alberta Environment and Sustainable Resource Development, 2011, *Alberta CWCS High – Resolution Wetland Inventory*, *https://maps.srd.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7B7A280790-2D88-4486-9D6A-B8CC2F6FEF1E%7D* (accessed March 2013). Environment Canada, 2012, *National Wetland Database,* Canadian Wildlife Service, Ottawa, Ontario. Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). Tarnocai, C., I.M. Kettles and B. Lacelle, 2011, *Peatlands of Canada*; Geological Survey of Canada, Open File 6561 (digital database); CD-ROM. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Table 2
Variables of demand for wetland services, indicators of demand for multiple services, southern Canada, 2011

	Sub-drainage area code	Area [1]	Indicators of demand for multiple services					
			Population	Population density	Land in agriculture	Livestock density	Average natural land parcel size	Average distance to natural land parcel
	code	square kilometres	persons	persons per square kilometre	percent of area	animals per square kilometre	square kilometres	metres
Saint John and Southern Bay of Fundy	01A	41,987	413,990	9.9	8.5	70	57.0	14
Gulf of St. Lawrence and Northern Bay of Fundy	01B	60,653	452,765	7.5	3.2	2	88.6	6
Prince Edward Island	01C	5,943	140,204	23.6	40.5	96	2.3	229
Bay of Fundy and Gulf of St. Lawrence, Nova Scotia	01D	21,499	319,417	14.9	14.8	203	19.9	26
Southeastern Atlantic Ocean, Nova Scotia	01E	23,222	466,559	20.1	3.0	21	39.8	4
Cape Breton Island	01F	10,685	135,933	12.7	2.4	1	38.0	6
Northwestern Lake Superior	02A	51,541	131,349	2.5	0.5	0 s	104.2	1
Northeastern Lake Superior	02B	61,283	42,043	0.7	0 s	0 s	213.1	0
Northern Lake Huron	02C	45,421	257,964	5.7	2.5	1	57.1	3
Wanapitei and French, Ontario	02D	19,669	92,832	4.7	2.4	3	61.7	3
Eastern Georgian Bay	02E	28,778	796,438	27.7	13.0	66	6.3	86
Eastern Lake Huron	02F	33,728	314,290	9.3	29.6	448	0.8	404
Northern Lake Erie	02G	35,302	2,204,745	62.5	46.9	709	0.3	580
Lake Ontario and Niagara Peninsula	02H	39,336	7,394,483	188.0	22.4	265	2.7	247
Upper Ottawa	02J	50,670	109,703	2.2	3.5	2	39.9	9
Central Ottawa	02K	40,753	475,802	11.7	7.7	5	23.7	22
Lower Ottawa	02L	54,719	1,373,928	25.1	10.9	57	12.7	56
Upper St. Lawrence	02M	6,139	272,852	44.4	36.8	140	1.9	264
Saint-Maurice	02N	42,251	125,895	3.0	0.3	3	95.6	1
Central St. Lawrence	02O	35,600	4,989,375	140.2	39.4	794	4.3	245
Lower St. Lawrence	02P	37,780	1,247,461	33.0	22.3	256	10.4	70
Northern Gaspé Peninsula	02Q	13,383	128,780	9.6	13.5	27	19.5	30
Saguenay	02R	88,072	276,001	3.1	2.3	7	102.0	8
Betsiamites, coast	02S	27,473	13,750	0.5	0.2	0 s	152.4	0
Northern Newfoundland	02Y	66,153	155,994	2.4	0.2	0 s	102.2	0
Southern Newfoundland	02Z	44,441	331,797	7.5	0.4	25	71.1	1
Nottaway, coast	03A	67,938	23,793	0.4	0.2	0 s	155.2	0
Kenogami	04J	52,370	6,799	0.1	0 s	0 s	386.2	0 s
Missinaibi and Mattagami	04L	60,593	57,879	1.0	0.1	0 s	489.3	0
Abitibi	04M	29,291	43,125	1.5	3.0	1	56.5	9
Harricanaw, coast	04N	43,509	57,810	1.3	0.8	4	239.1	2
Upper South Saskatchewan	05A	46,410	266,878	5.8	84.8	108	2.2	595
Bow	05B	25,628	1,313,058	51.2	55.6	39	3.8	324
Red Deer	05C	50,315	265,648	5.3	82.2	94	1.3	566
Upper North Saskatchewan	05D	27,983	439,197	15.7	21.0	18	7.3	107
Central North Saskatchewan	05E	42,275	889,643	21.0	78.2	74	0.6	650
Battle	05F	30,241	130,578	4.3	87.7	110	0.3	826
Lower North Saskatchewan	05G	49,652	99,464	2.0	80.1	29	0.7	807
Lower South Saskatchewan	05H	55,268	324,195	5.9	88.2	58	0.8	1,102
Qu'Appelle	05J	74,589	333,203	4.5	86.1	26	0.5	1,295
Saskatchewan	05K	81,194	64,292	0.8	16.3	4	12.3	234
Lake Winnipegosis and Lake Manitoba	05L	82,719	82,868	1.0	36.2	22	3.5	209
Assiniboine	05M	51,259	345,025	6.7	74.9	50	0.7	500
Souris	05N	39,591	69,291	1.8	87.3	19	0.6	1,062
Red	05O	25,266	717,652	28.4	74.8	350	0.6	476
Winnipeg	05P	55,104	56,068	1.0	2.5	7	20.1	7
English	05Q	52,550	26,718	0.5	0.2	0 s	40.4	0
Eastern Lake Winnipeg	05R	63,642	4,665	0.1	0.0	0	101.4	0
Western Lake Winnipeg	05S	41,819	32,851	0.8	9.7	11	9.0	72
Beaver, Alberta and Saskatchewan	06A	49,940	63,563	1.3	23.7	6	8.6	87
Upper Athabasca	07A	34,856	43,284	1.2	4.1	1	94.6	7
Central Athabasca, upper	07B	40,496	59,482	1.5	25.2	16	6.6	121
Central Athabasca, lower	07C	57,030	38,192	0.7	3.8	2	48.9	13
Smoky	07G	51,508	102,125	2.0	20.9	6	11.0	99
Nass, coast	08D	29,036	2,438	0.1	0.0	0	327.8	0
Skeena, coast	08E	55,751	55,522	1.0	1.3	0 s	517.3	0
Central coastal waters, British Columbia	08F	54,658	13,528	0.2	0.2	0 s	96.9	0 s

See notes at the end of the table.

Table 2 – continued

Variables of demand for wetland services, indicators of demand for multiple services, southern Canada, 2011

	Sub-drainage area code	Area [1]	Indicators of demand for multiple services					
			Population	Population density	Land in agriculture	Livestock density	Average natural land parcel size	Average distance to natural land parcel
	code	square kilometres	persons	persons per square kilometre	percent of area	animals per square kilometre	square kilometres	metres
Southern coastal waters, British Columbia	08G	41,986	687,662	16.4	0.3	13	183.3	2
Vancouver Island	08H	34,882	737,398	21.1	1.4	20	93.7	4
Nechako	08J	47,332	61,488	1.3	4.4	1	248.0	2
Upper Fraser	08K	67,088	73,650	1.1	3.0	1	734.5	1
Thompson	08L	55,777	185,393	3.3	10.1	25	381.0	2
Lower Fraser	08M	61,880	2,018,645	32.6	5.4	281	80.6	10
Columbia	08N	102,925	488,653	4.7	3.1	7	390.6	2
Queen Charlotte Islands	08O	10,049	4,370	0.4	0 s	0	83.4	0 s
Skagit	08P	1,027	140	0.1	0.3	0	1,021.5	0
Missouri	11A	27,097	8,701	0.3	84.9	0	3.4	366

1. Total area of the sub-drainage area including large bodies of water.

Note(s): Tables 1, 2 and 3 (Appendix F) present supply and demand indicators for wetland ecosystem goods and services organized using an accounting approach. Some duplication occurs within the tables.

Source(s): Statistics Canada, CANSIM tables 153-0035 and 153-0036 (accessed November 28, 2013). Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011. Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011,* Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Table 3
Variables of demand for wetland services, indicators of demand for individual services, southern Canada, 2011

	Sub-drainage area code	Area[1]	Streamflow regulation	Water quality regulation			Recreational and educational use	
			Flow variability[2]	Land area fertilized	Nitrogen in manure from livestock	Phosphorous in manure from livestock	Average natural land parcel size	Average distance to natural land parcel
	code	square kilometres	CV of flow in major river	percent of area	kilograms per square kilometre		square kilometres	metres
Saint John and Southern Bay of Fundy	01A	41,987	0.99	1.5	145	39	57.0	14
Gulf of St. Lawrence and Northern Bay of Fundy	01B	60,653	1.06	0.5	63	16	88.6	6
Prince Edward Island	01C	5,943	0.67	16.8	818	215	2.3	229
Bay of Fundy and Gulf of St. Lawrence, Nova Scotia	01D	21,499	0.75	2.6	353	93	19.9	26
Southeastern Atlantic Ocean, Nova Scotia	01E	23,222	0.75	0.5	38	10	39.8	4
Cape Breton Island	01F	10,685	0.75	0.3	42	11	38.0	6
Northwestern Lake Superior	02A	51,541	0.53	0.1	11	3	104.2	1
Northeastern Lake Superior	02B	61,283	0.47	0 s	0 s	0 s	213.1	0
Northern Lake Huron	02C	45,421	0.60	0.2	38	10	57.1	3
Wanapitei and French, Ontario	02D	19,669	0.58	0.3	31	8	61.7	3
Eastern Georgian Bay	02E	28,778	0.64	5.1	299	79	6.3	86
Eastern Lake Huron	02F	33,728	0.79	15.8	1,361	387	0.8	404
Northern Lake Erie	02G	35,302	0.70	29.7	1,616	464	0.3	580
Lake Ontario and Niagara Peninsula	02H	39,336	0.08	7.7	554	148	2.7	247
Upper Ottawa	02J	50,670	0.25	0.8	64	16	39.9	9
Central Ottawa	02K	40,753	0.49	1.2	168	44	23.7	22
Lower Ottawa	02L	54,719	0.40	3.8	322	82	12.7	56
Upper St. Lawrence	02M	6,139	0.56	14.1	971	247	1.9	264
Saint-Maurice	02N	42,251	0.37	0 s	7	2	95.6	1
Central St. Lawrence	02O	35,600	0.52	17.3	1,815	522	4.3	245
Lower St. Lawrence	02P	37,780	1.04	4.1	1,090	307	10.4	70
Northern Gaspé Peninsula	02Q	13,383	1.23	1.8	405	104	19.5	30
Saguenay	02R	88,072	1.57	0.5	55	14	102.0	8
Betsiamites, coast	02S	27,473	0.34	0 s	4	1	152.4	0
Northern Newfoundland	02Y	66,153	0.35	0 s	7	2	102.2	0
Southern Newfoundland	02Z	44,441	0.26	0.1	26	7	71.1	1
Nottaway, coast	03A	67,938	0.56	0 s	2	1	155.2	0
Kenogami	04J	52,370	1.11	0 s	0 s	0 s	386.2	0
Missinaibi and Mattagami	04L	60,593	1.21	0 s	1	0 s	489.3	0
Abitibi	04M	29,291	0.65	0.3	67	18	56.5	9
Harricanaw, coast	04N	43,509	1.06	0 s	17	5	239.1	2
Upper South Saskatchewan	05A	46,410	1.04	29.5	1,723	471	2.2	595
Bow	05B	25,628	0.84	18.4	1,018	276	3.8	324
Red Deer	05C	50,315	1.05	27.1	1,283	350	1.3	566
Upper North Saskatchewan	05D	27,983	0.60	4.5	339	91	7.3	107
Central North Saskatchewan	05E	42,275	0.60	32.5	934	254	0.6	650
Battle	05F	30,241	1.68	42.3	1,236	337	0.3	826
Lower North Saskatchewan	05G	49,652	0.63	34.7	516	141	0.7	807
Lower South Saskatchewan	05H	55,268	0.58	36.0	534	145	0.8	1,102
Qu'Appelle	05J	74,589	1.27	39.4	544	149	0.5	1,295
Saskatchewan	05K	81,194	0.56	8.7	68	19	12.3	234
Lake Winnipegosis and Lake Manitoba	05L	82,719	0.83	12.6	378	105	3.5	209
Assiniboine	05M	51,259	1.03	34.3	650	182	0.7	500
Souris	05N	39,591	2.29	41.2	691	190	0.6	1,062
Red	05O	25,266	1.06	46.2	1,330	415	0.6	476
Winnipeg	05P	55,104	0.46	0.5	42	12	20.1	7
English	05Q	52,550	0.79	0 s	2	1	40.4	0
Eastern Lake Winnipeg	05R	63,642	0.96	0.0	0	0	101.4	0
Western Lake Winnipeg	05S	41,819	2.01	3.1	114	33	9.0	72
Beaver, Alberta and Saskatchewan	06A	49,940	1.12	3.7	292	79	8.6	87
Upper Athabasca	07A	34,856	0.69	0.6	68	18	94.6	7
Central Athabasca, upper	07B	40,496	0.91	6.7	441	119	6.6	121
Central Athabasca, lower	07C	57,030	0.63	0.8	44	12	48.9	13
Smoky	07G	51,508	1.10	8.4	164	45	11.0	99
Nass, coast	08D	29,036	0.86	0.0	0	0	327.8	0
Skeena, coast	08E	55,751	0.97	0.1	17	5	517.3	0
Central coastal waters, British Columbia	08F	54,658	0.54	0 s	2	1	96.9	0

See notes at the end of the table.

Table 3 – continued

Variables of demand for wetland services, indicators of demand for individual services, southern Canada, 2011

	Sub-drainage area code	Area [1]	Streamflow regulation	Water quality regulation			Recreational and educational use	
			Flow variability [2]	Land area fertilized	Nitrogen in manure from livestock	Phosphorous in manure from livestock	Average natural land parcel size	Average distance to natural land parcel
	code	square kilometres	CV of flow in major river	percent of area	kilograms per square kilometre		square kilometres	metres
Southern coastal waters, British Columbia	08G	41,986	0.82	0 s	9	2	183.3	2
Vancouver Island	08H	34,882	0.41	0.3	66	17	93.7	4
Nechako	08J	47,332	0.72	0.6	64	17	248.0	2
Upper Fraser	08K	67,088	0.81	0.3	42	11	734.5	1
Thompson	08L	55,777	0.88	0.4	164	43	381.0	2
Lower Fraser	08M	61,880	0.59	0.8	325	88	80.6	10
Columbia	08N	102,925	0.34	0.3	48	13	390.6	2
Queen Charlotte Islands	08O	10,049	0.75	0.0	1	0 s	83.4	0
Skagit	08P	1,027		0.0	31	7	1,021.5	0
Missouri	11A	27,097	2.40	0.0	589	161	3.4	366

1. Total area of the sub-drainage area including large bodies of water.
2. Flow variability is represented by the coefficient of variation calculated using monthly streamflow values for the years 1990 to 2010 for rivers with the highest streamflow in the sub-drainage area.

Note(s): Tables 1, 2 and 3 (Appendix F) present supply and demand indicators for wetland ecosystem goods and services organized using an accounting approach. Some duplication occurs within the tables.

Source(s): Statistics Canada, CANSIM table 153-0035 (accessed October 8, 2013). Environment Canada, 2010, *Archived Hydrometric Data (HYDAT),* Water Survey of Canada. Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011. Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011,* Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Appendix G

Thousand Islands National Park case study methodology

Case study area

This case study focused on several distinct areas for different components of the study (Map 4.1). The boundaries of these different areas are described below:

- Land cover: The Canadian portion of the Thousand Islands Ecosystem boundary delimits the zone analyzed for the land cover information.
- Pressures: In order to better depict the external influences on the park, a 100 km buffer around the Thousand Islands Ecosystem was created and served as a boundary for the pressures analysis, namely for the population and agriculture data. Any census consolidated subdivision (CCS)[1] that touched the 100 km buffer, or was found within it, was included in the pressures analysis.[2] Data in Table 4.1 Population and agriculture are presented for this 100 km buffer boundary and the Canadian portion of the Thousand Islands Ecosystem boundary.
- Valuation: The valuation component of the case study focused solely on the Thousand Islands National Park land fragments, a total of 22.3 km^2.

Methodology for the analysis of land cover

Several land cover compilation sources, each with varying levels of image resolution and spatial coverage, were compared to determine the land cover of both the Thousand Islands National Park and Thousand Islands Ecosystem.

Differences in the land cover by image source are presented in Tables 1 and 2 (Appendix G) at the 12-class land cover level,[3] which includes detailed forest land cover classes. Land cover classes were determined based on the commonality of the classes between the different image sources.

1. The 2011 CSS boundary was used for both 1981 and 2011 data. Because Census boundaries are different between 1981 and 2011, the 1981 data were compiled to match the 2011 boundary and therefore ensures comparability between the two years.
2. For confidentiality reasons, data for CCS located within the 100 km buffer may also have been merged with data for CCS adjacent to the buffer zone. These merged areas were included in the pressures analysis.
3. Two of the land cover classes (snow and ice and sparse conifer) do not occur in the study area.

Table 1
Land cover statistics, selected compilations, Thousand Islands Ecosystem

	Thousand Islands Ecosystem									
	AAFC land cover, 30 m, 2011		CCRS land cover, 250 m, 2011		SOLRIS, 15 m, 2008		MEGS geospatial database, 250 m[1], 2011		Parks Canada LANDSAT-TM, 30 m, 2007	
	hectares	percent	hectares	percent	hectares	percent	hectares	percent	hectares	percent
Evergreen forest	6,443	3.5	2,880	1.6	1,575	0.9	1,321	0.7	1,773	1.0
Deciduous forest	27,123	14.9	60,921	33.4	20,639	11.3	53,906	29.6	29,991	16.5
Mixedwood	21,609	11.9	8,883	4.9	22,803	12.5	6,002	3.3	24,242	13.3
Shrubland	21,072	11.6	3,595	2.0	0	0.0	2,831	1.6	19,380	10.6
Grassland	297	0.2	1,402	0.8	0	0.0	1,624	0.9	10	0[s]
Barrenland	636	0.3	6	0[s]	66,793	36.7	0[s]	0[s]	2	0[s]
Wetland	9,835	5.4	1,775	1.0	21,805	12.0	8,705	4.8	12,939	7.1
Cropland and field	47,083	25.8	57,104	31.3	1,010	0.6	52,713	28.9	43,219	23.7
Built-up	5,673	3.1	1,292	0.7	7,579	4.2	6,188	3.4	10,313	5.7
Water natural and artifical	42,402	23.3	44,315	24.3	39,970	21.9	48,886	26.8	40,306	22.1

1. Base layer of the geodatabase is 250 m; additional datasets improve overall resolution.

Source(s): Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011,* Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Ontario Ministry of Natural Resources, Science and Information Branch, 2008, *Southern Ontario Land Resource Information System (SOLRIS)*. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation. Parks Canada, Natural Resource Conservation, 2012, special tabulation, Land Cover Map of the Greater Thousand Islands National Park Ecosystem using Landsat Thematic Mapper and Random Forest Models, LANDSAT 5.

Table 2
Land cover statistics, selected compilations, Thousand Islands National Park

	Thousand Islands National Park									
	AAFC land cover, 30 m, 2011		CCRS land cover, 250 m, 2011		SOLRIS, 15 m, 2008		MEGS geospatial database, 250 m[1], 2011		Parks Canada LANDSAT-TM, 30 m, 2007	
	hectares	percent	hectares	percent	hectares	percent	hectares	percent	hectares	percent
Evergreen forest	160	7.2	80	3.6	97	4.4	97	4.4	25	1.1
Deciduous forest	537	24.1	1,318	59.1	264	11.9	1,257	56.4	605	27.2
Mixedwood	1,132	50.8	313	14.0	1,236	55.5	249	11.2	1,207	54.1
Shrubland	28	1.2	31	1.4	0	0.0	32	1.4	74	3.3
Grassland	0	0.0	131	5.9	0	0.0	185	8.3	0	0.0
Barrenland	6	0.3	0	0.0	224	10.1	0	0.0	0	0.0
Wetland	251	11.3	113	5.1	362	16.2	245	11.0	223	10.0
Cropland and field	40	1.8	25	1.1	15	0.7	14	0.6	37	1.7
Built-up	20	0.9	0	0.0	19	0.8	24	1.1	49	2.2
Water natural and artifical	56	2.5	219	9.8	12	0.5	126	5.7	8	0.4

1. Base layer of the geodatabase is 250 m; additional datasets improve overall resolution.

Source(s): Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). Natural Resources Canada, 2012, *Canada 250m Land Cover Time Series 2000-2011,* Earth Sciences Sector, Canada Centre for Remote Sensing, *ftp://ftp.ccrs.nrcan.gc.ca/ad/Pouliot/LCTS/LCTS_V1/* (accessed May 8, 2013). Ontario Ministry of Natural Resources, Science and Information Branch, 2008, *Southern Ontario Land Resource Information System (SOLRIS)*. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation. Parks Canada, Natural Resource Conservation, 2012, special tabulation, Land Cover Map of the Greater Thousand Islands National Park Ecosystem using Landsat Thematic Mapper and Random Forest Models, LANDSAT 5.

Instead of Canada Centre for Remote Sensing (CCRS) land cover, the reference land cover product for the Measuring Ecosystem Goods and Services (MEGS) project, Parks Canada LANDSAT-TM land cover was chosen to represent the land cover of the Thousand Islands National Park and Thousand Islands Ecosystem because:

- wetlands are better represented in Parks Canada LANDSAT-TM than in CCRS land cover
- the finer resolution is better suited for small area analysis
- Parks Canada LANDSAT-TM is the image source used by Parks Canada for their analyses

- Parks Canada LANDSAT-TM would also permit future analysis of parks in other areas of the country
- Parks Canada LANDSAT-TM land cover classes are a good representation of Canada's land cover; however, no time-series exist for Parks Canada LANDSAT-TM.

Valuation of ecosystem goods and services by land cover type

The overall value of ecosystem services by land cover was estimated using existing monetary values of ecosystem goods and services (EGS) taken from a 2009 report by Troy and Bagstad, *Estimating Ecosystem Services in Southern Ontario*. Dollar values per hectare were weighted based on land cover areas for each of the data sources used in the analysis of land cover. The use of different land cover sources resulted in significant variations in the estimates of the value of the park's EGS, highlighting the sensitivity of the valuations to the resolution of land cover data.

Methodology for applying monetary values from Troy and Bagstad (2009) to the Thousand Islands National Park

The GIS layers used include the Thousand Islands National Park protected areas layer (excluding islets, Mainduck and Yorkshire Islands) and the Troy and Bagstad land cover and monetary valuation layer. The case study took the values per hectare from Troy and Bagstad and extracted the monetary data found for the park area, using the polygons for the park confirmed by Parks Canada. For each satellite data source, the Thousand Islands National Park protected areas layer was used to identify the land cover present in the park.

In order to compute monetary values for all land cover compilations used in the case study, a weighted average valuation method was applied. The Troy and Bagstad land cover classifications were organized and grouped to the MEGS eight-class land cover, the highest level of detail possible from this source. For each land cover class, the various Troy and Bagstad categories were weighted according to the land area that they covered in the park. For each land cover data source, the land cover classes were rolled-up to match the MEGS eight-category classification. Each category was then multiplied by the weighted average generated from the original study (dollars per hectare).

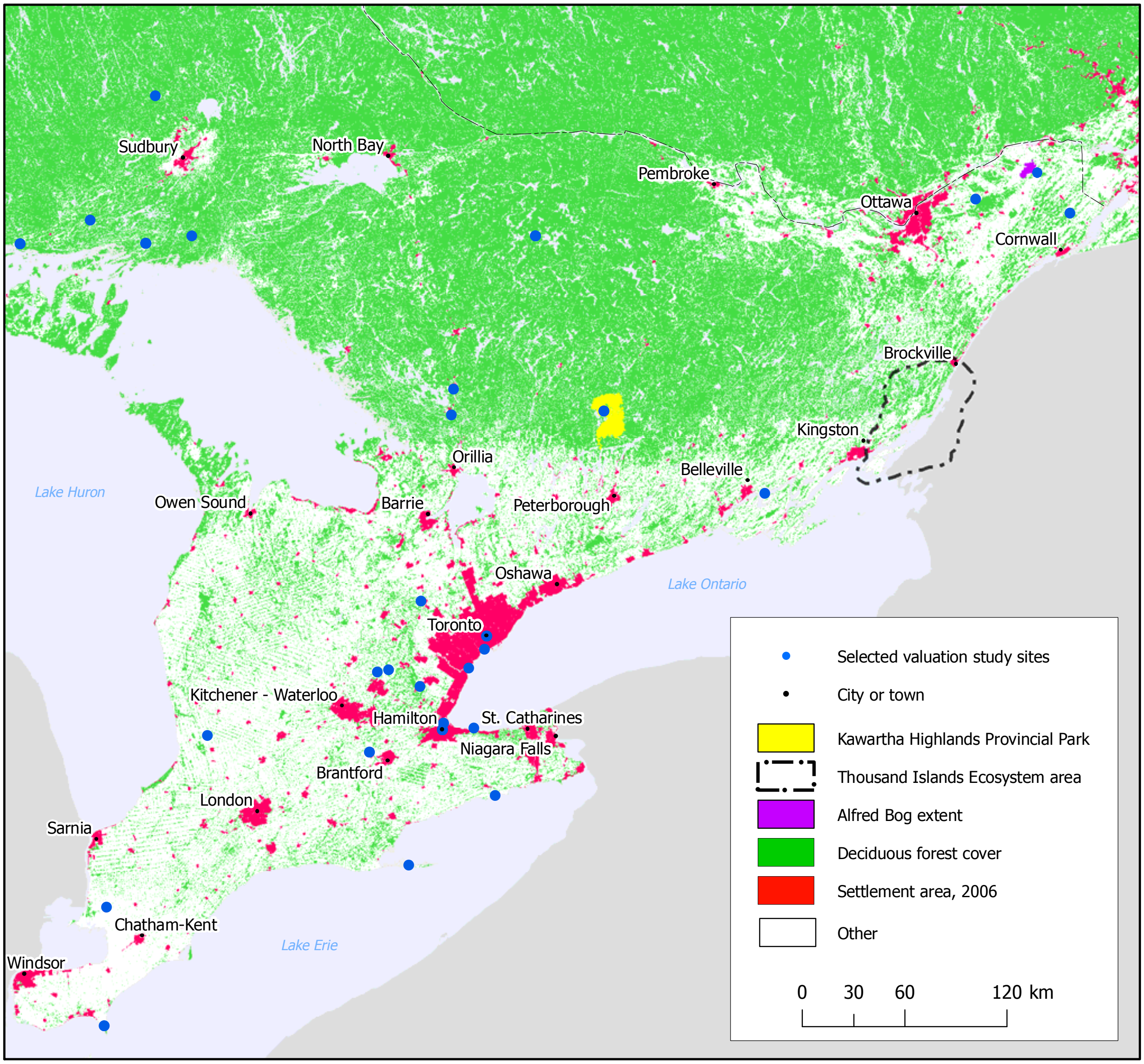
Valuation of individual ecosystem goods and services in the Thousand Islands National Park, by land cover type

Selecting the study sites

To facilitate comparisons between the Thousand Islands 'policy site' and potential study sites for benefit transfer, original valuation studies from across Canada were gathered, geo-spatially referenced, and incorporated into the MEGS geospatial database.[4] This geospatial framework links each study site with a variety of data that describe its physical land cover characteristics and socio-economic context, including proximity to settled areas. As noted in Appendix A, characteristics of land cover ecosystem units (LCEU), such as terrain ruggedness and land cover, are closely tied with the types of ecosystem services that that land area may have the potential to provide. Establishing these links for each study site helps analysts decide which study sites have the potential to be used as 'donors' of ecosystem service values for the policy site valuation exercise. In Map 1 (Appendix G) selected geo-spatially referenced study sites for the southern Ontario region are overlaid with deciduous forest land cover and the settlements footprint map layers.

4. Studies were taken from the Environmental Valuation Reference Inventory (EVRI) as well as other sources.

Map 1
Selected valuation study sites in southern Ontario



Source(s): Environment Canada, 2011, *Environmental Valuation Reference Inventory (EVRI)*, www.evri.ca (accessed July 11, 2013). Statistics Canada, 2010, "Introducing a New Concept and Methodology for Delineating Settlement Boundaries: A Research Project on Canadian Settlements," *Environment Accounts and Statistics Analytical and Technical Paper Series*, Catalogue no. 16-001-M, no. 11. Statistics Canada, Environment Accounts and Statistics Division, 2013, special tabulation.

Ecosystem services values within a site are a function of underlying biophysical characteristics. However, they are also influenced by the type of beneficiaries (e.g., number, income and preferences) of the ecosystem's services, as well as by the availability of substitute and complementary sites and services.[5] These aspects are taken into account when selecting potential sites from which to transfer benefit values, using information provided by the geospatial database, including spatially referenced socio-economic data in conjunction with information provided within the studies themselves, to conduct analysis of potential sites.

Transferring the unit values

Having chosen study sites that aligned as closely as possible with the policy site, the next step was to transfer ecosystem service values from the study sites to the Thousand Island National Park policy site, based on specific targets. Depending on the type of value being transferred, the targets were expressed in dollars per household per unit area (hectares) per year, as in the case of option, bequest and existence values,[6] or as dollars per person per year, as in the case of recreation values.[7]

Adjusting the unit values

While a close alignment between study and policy sites is a key requirement of any unit transfer exercise, transferred values can be further adjusted for socio-economic differences that exist between sites.[8] Individuals' willingness to pay for any good or service is dependent upon their socio-economic circumstances in addition to many other factors, such as values and beliefs of the beneficiaries of services. Regarding socio-economic circumstances, a number of studies[9] have shown that the willingness to pay for ecosystem services rises along with increases in household income. For this reason, transferred values for the Thousand Islands National Park were adjusted to account for inter-site differences in income.

Adjusting unit values requires statistically sound socio-economic information gathered and reported on a spatial basis for both the original study site and the policy site. Use of the MEGS geospatial framework facilitated the adjustments.

The Thousand Island National Park has the potential to provide a wide variety of services to beneficiaries in and around the park. The experimental valuation exercise considered a sub-set of these services: recreation and option, bequest and existence values.

5. Brander, L., A. Ghermandi, O. Kuik, A. Markandya, P.A.L.D. Nunes, M. Schaafsma and A. Wagtendonk, 2010, "Scaling up Ecosystem Services Values: Methodology, Applicability and a Case Study," *Fondazione Eni Enrico Mattei Working Paper Series*, Issue 9.
6. Values were taken from Tkac, J.M., 2002, *Estimating Willingness to Pay for the preservation of the Alfred Bog wetland in Ontario: A multiple bounded discrete choice approach*, McGill University, *http://digitool.library.mcgill.ca/R/?func=dbin-jump-full&object_id=29480&local_base=GEN01-MCG02* (accessed August 12, 2013). See Map 1 (Appendix G), Valuation study sites in southern Ontario, to view the location of the study site from which these values were transferred, labeled 'Alfred Bog extent.'
7. Values were taken from Shantz, P., K. Rollins, L. Johnson and W. Wistowsky, 2004, *A study of the economic and social benefits of the nine Ontario Living Legacy Signature Sites*, *http://casiopa.mediamouse.ca/wp-content/uploads/2010/05/PRFO-2004-Proceedings-p267-279-Shantz-Wistowsky-Rollins-and-Johnson.pdf* (accessed August 12, 2013). See Map 1 (Appendix G), Valuation study sites in southern Ontario, to view the location of the study site from which these values were transferred, labeled 'Kawartha Highlights Provincial Park.'
8. Ruitenbeek, J., Personal communication, June 30, 2012.
9. Hökbya, S. and T. Söderqvist, 2003, "Elasticities of demand and willingness to pay for environmental services in Sweden," *Environment and Resource Economics*, Vol. 26, Issue 3, pages 361 to 383.

Appendix H

Geographies

In Canada, land cover classifications have been established by government (federal, provincial and municipal) and non-government users.

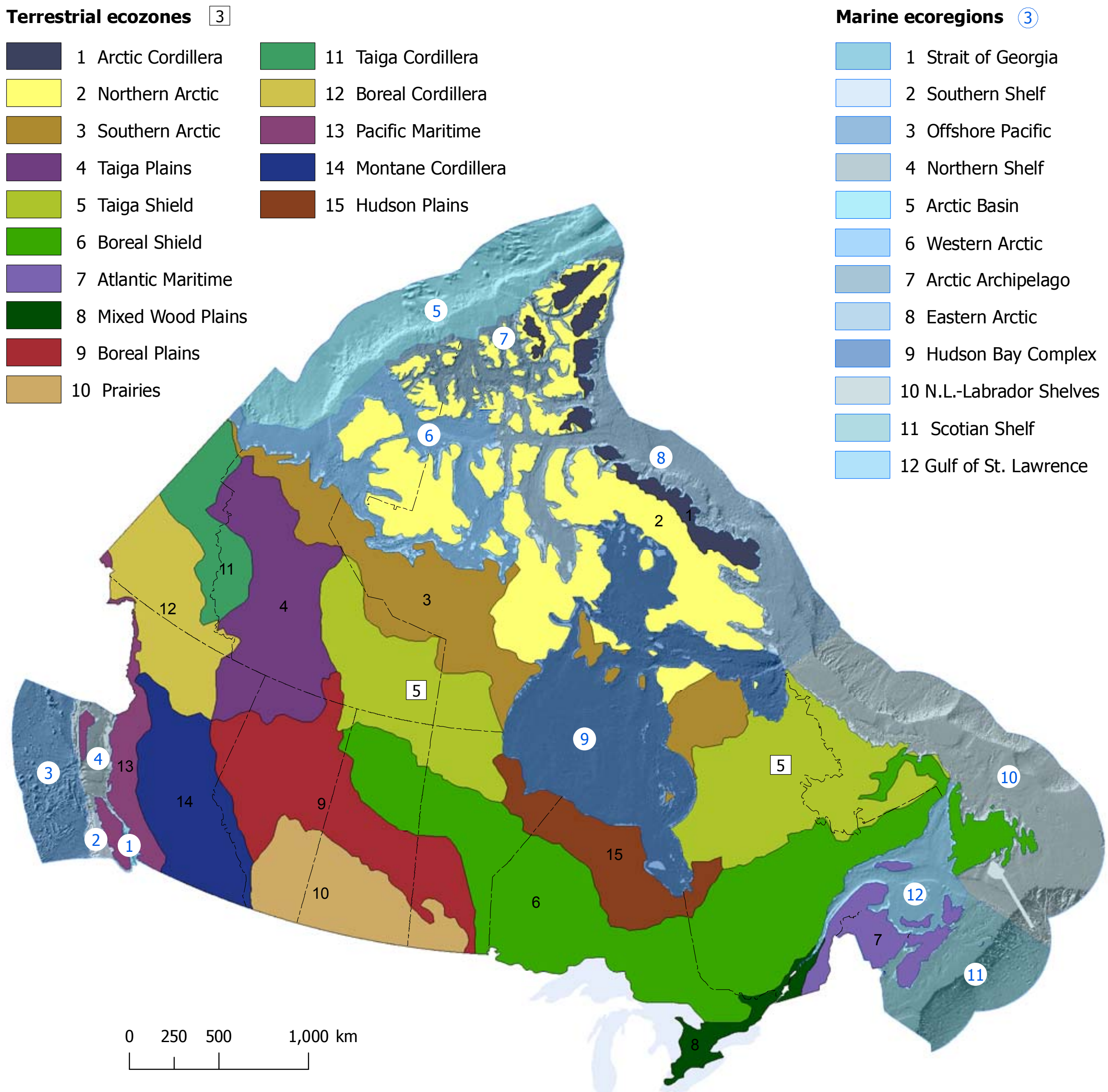
The Ecological Framework of Canada represents a national approach to terrestrial ecosystem classification and mapping based on biophysical characteristics.[1] At the highest level, this hierarchical classification system includes 15 terrestrial ecozones. These large areas are further broken down into 53 ecoprovinces, 194 ecoregions and 1,021 ecodistricts, each characterized by greater levels of detail.

In addition, Fisheries and Oceans Canada identifies 12 ecoregions for Canada's three Oceans as part of its biogeographic classification framework for Canadian marine areas.[2]

Canada's terrestrial ecozones and marine ecoregions are identified in Map 1 (Appendix H).

1. Agriculture and Agri-Food Canada and Environment Canada, 2013, *A National Ecological Framework for Canada*, *http://sis.agr.gc.ca/cansis/nsdb/ecostrat/index.html* (accessed July 17, 2013).
2. Fisheries and Oceans Canada, 2009, *Development of a Framework and Principles for the Biogeographic Classification of Canadian Marine Areas*, Fisheries and Oceans Canada Canadian Science Advisory Secretariat, Scientific Advisory Report 2009/056.

Map 1
Terrestrial ecozones and marine ecoregions of Canada



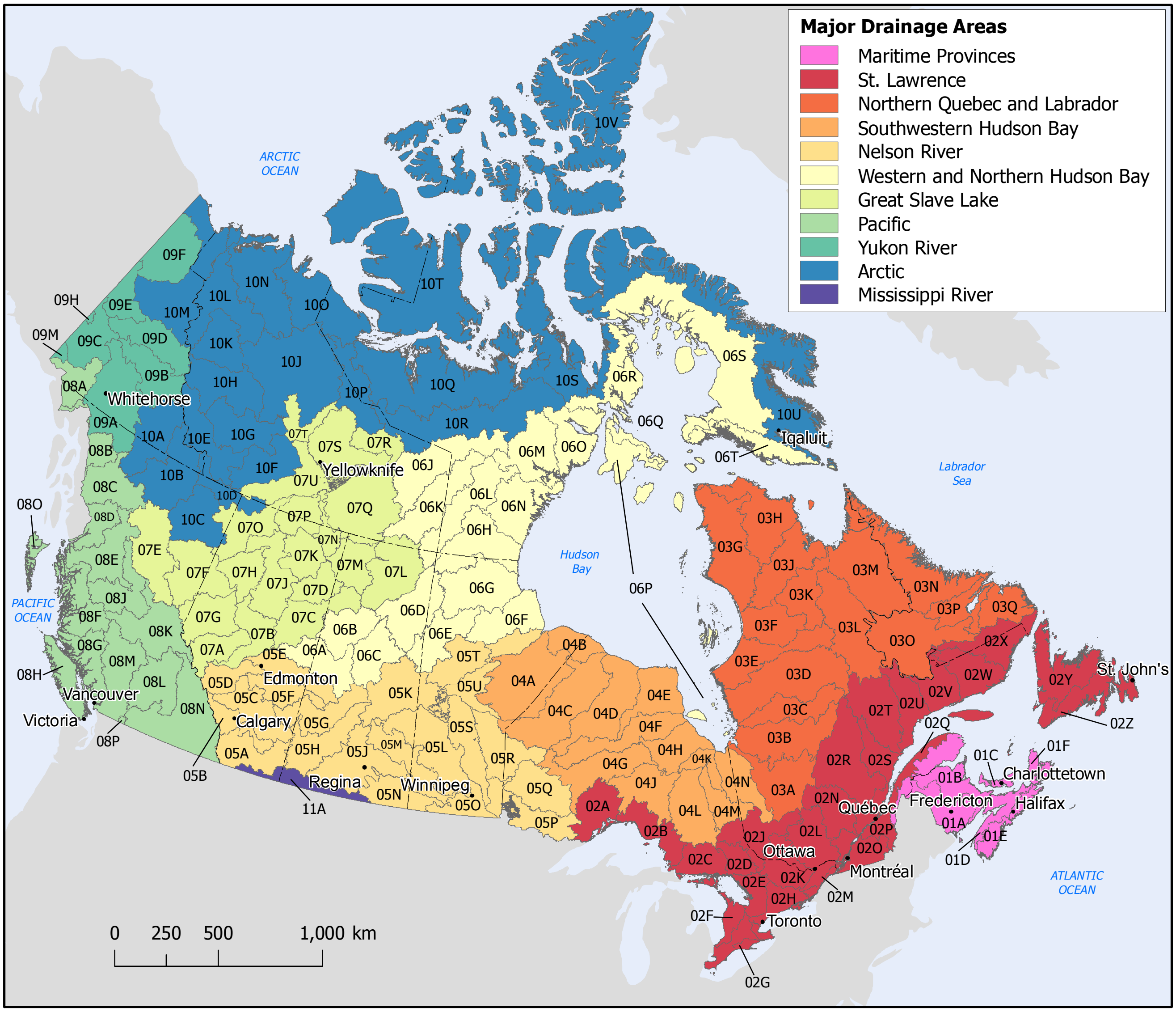
Source(s): Wiken, E.B., D. Gauthier, I. Marshall, K. Lawton and H. Hirvonen, 1996, *A Perspective on Canada's Ecosystems: An Overview of the Terrestrial and Marine Ecozones*, Canadian Council on Ecological Areas, Occasional Paper, no. 14, Ottawa. Fisheries and Oceans Canada, 2009, *Development of a Framework and Principles for the Biogeographic Classification of Canadian Marine Areas*, Fisheries and Oceans Canada Canadian Science Advisory Secretariat, Scientific Advisory Report 2009/056.

bb

Statistics Canada's Standard Drainage Area Classification (SDAC) 2003 was developed to enable the production of integrated statistics by hydrographic areas (Map 2, Appendix H). It provides a range of geographical units that are convenient for data collection and compilation, and useful for spatial analysis of environmental, economic and social statistics.[3]

3. Statistics Canada, 2009, *Standard Drainage Area Classification (SDAC) 2003*, *www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdac-ctad-eng.htm* (accessed July 15, 2013).

Map 2
Sub-drainage areas



Note(s): For more information, see Statistics Canada, Standards Division, 2009, *Standard Drainage Area Classification (SDAC) 2003*, www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdac-ctad-eng.htm (accessed October 15, 2013).

Source(s): Natural Resources Canada, 2003, National Scale Frameworks Hydrology – Drainage Areas, Canada, Version 5.0, www.geogratis.cgdi.gc.ca (accessed September 16, 2003). Statistics Canada, Environment Accounts and Statistics Division, Spatial Environmental Information System.

Appendix I

Glossary, abbreviations and equivalencies

Glossary

Biomass: the quantity or mass of organic material that is produced by or derived from living or recently living organisms, including products from forestry, agriculture and fisheries.

Carbon cycle: the continuous process by which carbon flows among the atmosphere, land, water and biota.

Carbon sequestration: the process of removing atmospheric CO_2, through biological processes (e.g., photosynthesis), geological processes (e.g., formation of limestone) or through dissolution in oceans.

Cultural services: are generated from the physical setting and location of ecosystems and give rise to emotional, intellectual and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection.

Dependable agricultural land: agricultural land classes 1 through 3 in the Canada Land Inventory. These classes include all land areas that are not hampered by severe constraints for crop production.

Ecosystem accounts: systematic grouping of information for assessing the capacity of ecosystems to deliver services to present and future generations and to monitor and value the flows of services.

Ecosystem flows: the stream of goods and services that are received from the ecosystem stock over time.

Ecosystem functions: the services performed by ecosystems such as energy flow, nutrient cycling, filtering, sequestration and breakdown of contaminants, or regulation of populations.

Ecosystem goods and services: the tangible goods (e.g., fish, timber) and less tangible services (e.g., clean air, productive soil) that arise from ecosystem structures and functions and that provide benefits to people.

Ecosystem potential: the ecosystem's capacity to provide a service.

Ecosystems: ecological communities of living species that interact with their environment and function as a unit. For accounting purposes, the concept is generalized, with ecosystems defined as the area where living species interact among themselves and with their environment.

Ecosystem stock: refers to the natural capital asset—the ecosystems—measured at a point in time.

Ecumene: inhabited land where people have made their permanent home, and to all work areas that are considered occupied and used for any economic purpose.

Eutrophication: the over-enrichment of an ecosystem with nutrients. In water, it results in excessive growth of aquatic plants, such as algae and the subsequent depletion of dissolved oxygen as the plants breakdown after they die. This oxygen depletion can change the composition of the aquatic community and, in extreme cases cause the death of other organisms such as fish.

Existence value: a type of non-use value obtained simply from knowing about the existence of a good or service (e.g., people may benefit from knowing about a remote park or wilderness area despite the fact they may never actually visit this area).

Final goods and services: goods and services that are available for purchase or use with no further transformations or input in the production of the good or service.

Greenbelt: area of environmentally sensitive land and farmland in southern Ontario's Golden Horseshoe region that has been protected from urban development and sprawl by the Ontario *Greenbelt Act, 2005*.

Groundfish: fish that live near the ocean bottom, such as cod or halibut.

Human Landscape Modification (HLM): an assessment method used in this report to describe and indicate the degree that human activities have modified natural intact areas.

Intermediate goods and services: goods and services that are used as inputs or components in the production of final goods and services.

Land cover: description of the physical nature of the land's surface, land cover classes are derived from satellite imagery.

Land use: dominant activity taking place on an area of land (agriculture, residences, etc.).

Natural capital asset: stocks of natural ecosystems that yield a flow of valuable ecosystem goods or services.

Natural and naturalizing land area; natural and naturalizing landscapes: land area including forests, wetlands, barrenlands, grasslands and shrublands that is classified as having predominantly natural or naturalizing characteristics. Naturalizing land areas have previously been modified from their natural state, but have been left undisturbed and are transitioning to a more natural land cover (e.g., cleared land reverting to forest area). The new natural state may or may not be similar to the original natural land cover.

Natural land parcel: natural and/or naturalizing land areas including forests, wetlands, barrenlands, grasslands and shrublands.

Provisioning services: the 'goods' in ecosystem goods and services (EGS)—they reflect the material and energy provided by ecosystems; for example, timber, fish, or plants that have a particular socio-economic use.

Peatlands: peatlands are organic wetlands, which contain accumulations of partially decayed plant matter. They include bogs, fens and swamps and are typically found in the north.

Pelagic fish: fish that normally live at or near the sea surface or in the water column, such as herring and tuna.

Pothole wetlands: depression wetlands on the Prairies that can occur on a continuous or sporadic and that can be connected or unconnected to streams, rivers and other surface water. These wetlands form in potholes created as glaciers retreated from the landscape.

Riparian: related to or located on the banks of a river, stream, lake or other body of water.

Regulating services: result from the capacity of ecosystems to regulate climatic, hydrological and bio-chemical cycles, as well as biological processes

Streamflow: the rate at which a volume of water passes a given point in a stream.

Sub-drainage area (SDA): represent areas in which surface water is carried downstream by a drainage system into a body of water. The SDA is a level in Statistics Canada's Standard Drainage Area Classification, 2003 hierarchy.

Total suspended solids (TSS): the total amount of particulate matter that is suspended in the water column.

Turbidity: cloudiness of a liquid caused by suspended particles and is used as a measure of water quality.

Valuation: the process of expressing a value for a particular good or service in a certain context (e.g., of decision-making) usually in terms of something that can be counted, often money.

Value, values: expression of significance or importance; can include material or monetary worth determined by the amount, relative worth, utility, or importance of an item.

Watershed: area draining naturally to a water course or other given point.

Water yield: the quantity of freshwater produced within a given area, e.g., a watershed.

Wetlands: lands transitional between terrestrial and aquatic systems where the water table is usually or seasonally at or near the surface or the land is covered by shallow water. Includes organic and mineral wetlands and can be further subdivided into five classes: marshes, swamps, bogs, fens, and shallow open waters.

Whitebelt: zone between the settled areas of the inner ring of municipalities circling Lake Ontario and the Greenbelt, to accommodate further urban growth and expansion in the coming decades.

Abbreviations and equivalences

Abbreviations

ha	hectare
kg	kilogram
km	kilometre
km^2	square kilometre
L	litre
NAICS	North American Industry Classification System
t	tonne

Equivalences

1 hectare =	1 km^2 / 100
1 km^2 =	100 hectares
1 tonne =	1,000 kilograms