Natural Capital Measurement at Statistics Canada

Current Status and Untapped Potential

Sustainable Prosperity

Midsummer Analytics

Produced by Sustainable Prosperity and Midsummer Analytics for the project

Linking Natural Capital & Productivity

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About the "Linking Natural Capital & Productivity" Project

The goal of this project is to shed light on the relationship between economic activity and the environment by exploring the linkages between changes in our natural capital and our measures of productivity generally, and through the construction of an environmentally adjusted measure of productivity specifically.

In addition, a primary goal of the project is to encourage the increased uptake of research into natural capital and its relationship economic performance more generally in Canadian universities, governments, think tanks and other research institutions. This paper aims to do so by presenting some possible research areas for discussion and -- hopefully – action.

More information about the project, including its partners, can be found on the project website.

About Sustainable Prosperity

Made up of business, environment, policy and academic leaders, Sustainable Prosperity (SP) is a national green economy think tank/do tank. We harness leading-edge thinking to advance innovation in policy and markets, in the pursuit of a greener, more competitive Canadian economy. At the same time, SP actively helps broker real-world solutions by bringing public and private sector decision-makers to the table with expert researchers to both design and apply innovative policies and programs. We believe that achieving the necessary innovation in policy and markets for a stronger, greener Canadian economy requires a new knowledge base and new conversations. SP's approach is to promote both by generating policy-relevant, expert knowledge to inform smart policy solutions and foster innovative conversations and connections.

About Midsummer Analytics

Midsummer Analytics is an Ottawa-based consultancy providing information and analysis to help understand issues found at the interface between the economy and the environment.

Executive Summary

Canadians enjoy immense wealth thanks in part to Canada's natural environment. As a country, Canada controls one of the largest primary resource bases in the world; ranked third in the world for each of forested area, renewable freshwater resources and oil reserves and ranked seventh for amount of arable land.[1] Canadians also benefit from the ecosystem services the environment provides – filtering of air by trees and absorption of floodwaters by plains and wetlands, among others. There is also the clean water provided to communities, the climate to grow crops and the natural beauty and biodiversity that provide cultural and spiritual wellbeing to many Canadians.

This natural asset – our "natural capital" – requires careful management in order to ensure its benefits are maintained for Canadians now and in the future. However, as the saying goes, "You can't manage what you don't measure."

Fortunately, Canada has a strong track record of natural capital measurement, largely due to efforts at Statistics Canada that began in the 1970s and continue until the present day. This report provides an overview of Statistics Canada's efforts to measure the state of Canada's natural capital (ecosystems, land and sub-soil resources), the demands placed upon it by human activities and the efforts undertaken to manage these demands. Both the agency's core environmental accounts and statistics and its various special studies relevant to natural capital are reviewed. Overviews are given of what is measured and its relevance to understanding natural capital (Part 2) and of the gaps and analytical opportunities related to the statistics (Part 3). A proposed research agenda is offered at the end of the report (Part 4).

The goals of this paper are to promote awareness of the valuable natural capital data Statistics Canada produces and to identify areas where further data collection and analysis could usefully be carried out, both by Statistics Canada and by outside researchers.

The need for data and analysis of natural capital is now greater than ever. Natural capital is increasingly at risk from over-exploitation, degradation from pollution, climate extremes and changing land uses, among other pressures. At the same time, the understanding of the importance of natural capital to well-being and sustainability is creating new demands for data to help guide policy. Greater uptake of research and analysis regarding natural capital can help inform policy formation – ultimately ensuring Canadians understand the benefits they obtain from their use of natural capital and the need to maintain those benefits for future generations.

[1] Sustainable Prosperity, 2014 "The Importance of Natural Capital to Canada's Economy" http://www.sustainableprosperity.ca/sites/default/files/publications/files/Importance%20of%20Natual%20Capital%20March%202014.pdf

Table of Contents

1 Introduction

This report provides an overview of Statistics Canada's efforts to measure the state of Canada's natural capital (ecosystems, land and sub-soil resources), the demands placed upon it by human activities and the efforts undertaken to manage these demands. Both the agency's core environmental accounts and statistics and its various special studies relevant to natural capital are reviewed. In all cases, overviews are given of what is measured and its relevance to natural capital (Part 2) and of the gaps and analytical opportunities related to the statistics (Part 3). A proposed research agenda is offered at the end of the report (Part 4). The report's goals are to promote awareness of the valuable natural capital data Statistics Canada produces and identify areas where further data collection and analysis could usefully be carried out, both by Statistics Canada and by outside researchers.

1.1 Four decades of measuring natural capital

Statistics Canada has had an active environmental statistics program since the field emerged as a distinct category of statistics in the 1970s. It was one of the first statistical offices anywhere to enter the field and has been one of the most active in the intervening years. The agency's well-deserved reputation for quality applies as much to environmental statistics as it does to the more established (and much larger[2]) programs of economic and social statistics.

1.1.1 Early efforts

The main output during the environment program's early years was a general reference compendium titled *Human Activity and the Environment.* The first such release was in 1978. They continued at roughly five-year intervals until 2000 when the compendium became an annual product. *Human Activity and the Environment* is still published today and remains a central feature of the environmental statistics program.

Around the same time that *Human Activity and the Environment* made its debut, Statistics Canada released a proposal for an environmental statistics framework that would gain influence around the world. Titled *Towards a Comprehensive Framework for Environmental Statistics: A Stress-Response Approach* (Statistics Canada, 1979), the proposal was quickly picked up and elaborated by a number of other organizations, most notably the OECD, where it the became known as the pressure-state-response (PSR) framework.[3] The PSR framework went on to form the basis of many environmental statistics programs.[4]

Another early innovation at Statistics Canada – and arguably the beginning of the agency's environmental accounting program – was the application of the emerging technology of geographic information systems (GIS) in the 1980s. GIS was used to recast standard Statistics Canada socio-economic data using spatial boundaries (ecoregions and watersheds) that reflected natural rather than political realities. For the first time, this allowed an ecologically based portrait of Canadians, their environment and their economy to be drawn. Such statistics featured prominently in the second edition of *Human Activity and the Environment* released in 1986. They were also used in Canada's first *State of the Environment Report* published by Environment Canada (jointly with Statistics Canada) in that same year.

[2] To put the size of the programs in perspective, of the 4,589 full-time equivalent staff positions at Statistics Canada in 2013/14 about 30 were devoted directly to environmental statistics (Statistics Canada Departmental Performance Report 2013/14).
[3] The PSR framework is also known today as the driving force-pressure-state-impact-response (DPSIR) framework, which has been popularized by the European Environment Agency.
[4] It is interesting to note that Statistics Canada itself was not one of the agencies to adopt the PSR framework. Rather, it experimented with a number of alternative approaches before finally settling upon the concept of natural capital as the basis for its environmental statistics program in 2013.

1.1.2 The development of the environmental accounting program

The late 1970s saw the beginning of formal efforts at environmental accounting in a few statistical offices around the world. Norway and France were leaders in these early efforts. A major impetus for others, including Canada, to join them came in the form of the 1987 report of the Brundtland Commission on environment and development – *Our Common Future* – which called upon nations to begin including the environment in their systems of national accounts (World Commission on Environment and Development, 1987). The Brundtland Commission's report recognized the need for integrated environmental and economic accounting in 1987 with a call for "an annual report and audit on changes in environmental quality and in the stock of the nation's environmental resource assets." Such reporting, the report noted, is "essential to obtain an accurate picture of the true health and wealth of the national economy, and to assess progress towards sustainable development" (World Commission on Environment and Development, 1987; p. 314).

The Brundtland Commission report was influential in the decision of the Mulroney government to table an ambitious *Green Plan for a Healthy Environment* in 1990 (Government of Canada, 1990). Among a wide range of initiatives designed to help achieve environmental sustainability, the *Green Plan* provided Statistics Canada with five million dollars over five years to "incorporate environmental components [into] Canada's traditional national accounts."[5]

Statistics Canada released its first set of environmental accounts in 1997 in a publication called *Econnections–Linking the Environment and the Economy: Detailed Accounts and Statistics* (Statistics Canada, 1997). The focus was on a set of 10 environment-economy indicators describing stocks of key natural resources, trends in land use, emissions of greenhouse gases, use of energy and water and expenditures to protect the environment. The detailed accounting data underlying the indicators were provided on an accompanying CD-ROM. An updated set of indicators/accounts was released under the same name in 2000.

Following the second release of the environmental accounts in 2000, Statistics Canada was invited by the National Roundtable on the Environment and Economy (NRTEE) to take part in a three-year exercise to develop a suite of sustainable development indicators at the request of then Minister of Finance, Paul Martin. This resulted in the NRTEE report *Environment and Sustainable Development Indicators for Canada*, which recommended "that Statistics Canada publish annually six easily understood, credible indicators" related to natural capital and human capital and that "the Government of Canada expand the System of National Accounts to include more detailed information on natural, human and, over time, social capital." (National Roundtable on the Environment and Economy, 2003) The eventual outcome of these recommendations was a government decision to have Statistics Canada jointly publish three environmental indicators (air quality, greenhouse gas emissions and water quality) with Environment Canada and Health Canada. The plan to expand the *System of National Accounts* was rejected by the government.

In order to make room for the new indicators, Statistics Canada's *Econnections* indicators publication was replaced with a joint report of Statistics Canada, Environment Canada and Health Canada titled *Canadian Environmental Sustainability Indicators* (Environment Canada et al., 2005).[6] This report was published three times (2005, 2006 and 2007) after which Statistics Canada lost the funding that had allowed its involvement in the partnership during a strategic review of government finances. The responsibility for publishing the indictors then fell entirely to Environment Canada, a responsibility that it carries on today in the form of a considerably expanded suite containing dozens of indicators.

Statistics Canada never again published its environmental accounts in a single package of indicators and data. It moved instead to releasing the accounting data in a series of annual tables in Statistics Canada's on-line database, CANSIM. No environment-economy indicators have been published by Statistics Canada since 2007, but a number of special studies drawing upon the environmental accounts have been released.[7]

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[5] Canada's *Green Plan* was never fully realized because of the defeat of the Mulroney government in 1993 and the replacement of the plan by the Chrétien government with an environmental strategy focused on building the environment industry (what would be referred to today as a green growth strategy).

[6] It should be noted that Statistics Canada continued to compile the same set of environmental accounts it began in 1997 even after the cancellation of the *Econnections* publication. It was only the publication that was cancelled and not the underlying statistical program.

[7] See, for example, the studies on natural resource wealth and household greenhouse gas emissions.

1.1.3 The development of the environmental survey program

This history of Statistics Canada's environmental accounts is only half of the story. In parallel to its world-class efforts related to environmental accounts, Statistics Canada was creating a world-class program of environmental surveys. Beginning in the early 1990s, the agency experimented with pilot surveys of household environmental behaviours, environmental protection expenditures, the environment industry and solid waste management. By the late 1990s, these pilots had turned into fully fledged surveys (except for the household survey, for which no funding was available). Much of this work was undertaken with funding provided by Industry Canada out of the above-mentioned environment industry strategy of the Chrétien government. The packaging waste disposal target (50% reduction by the year 2000) set by the Canadian Council of Ministers of the Environment was also a motivation for funding, in this case from Environment Canada.

The survey program expanded again in the mid-2000s, this time with internal funding from Statistics Canada. The household environmental behaviour survey was resurrected and supplementary surveys of in-home and private vehicle energy use were added. New surveys of water use were added for the agriculture, thermal electric power, mining, manufacturing and drinking water treatment industries. An experimental survey to measure industrial pollution emissions was attempted but not pursued beyond the pilot stage. Finally, a survey of farm environmental management practices funded by Agriculture and Agri-Food Canada was taken on by the environmental statistics team.

Today, Statistics Canada's environmental survey program comprises ten surveys covering solid waste management, environmental protection expenditures, environmental goods and services, household environmental behaviours and (in-home) energy use, water use and agricultural environmental management. It is without doubt one of the largest, longest running and most successful environmental survey programs in the world.

To complete this short history of Statistics Canada's environmental statistics program, the agency's contributions on the international stage, which have been significant, deserve mention. The agency's early influence on the development of the PSR framework has already been noted. This influence continued in the 1980s with contributions to various international meetings organized to coordinate development of basic concepts and methods for environmental statistics. However, the agency's pivotal contribution began in 1993. In that year, Statistics Canada, the United Kingdom Office for National Statistics and the United States Bureau of Economic Analysis jointly formed an international body to coordinate development in the emerging area of environmental accounting. The result was the London Group on Environmental Accounting, a group that has met annually since. Statistics Canada has twice served as chair of this group and twice hosted its meetings.

The London Group has been very influential in the field and can be credited with having conceived and developed what eventually became the first ever international standard in environmental statistics, the UN System of Environmental-Economic Accounts Central Framework. Statistics Canada made major intellectual and operational contributions, both inside and outside the London Group, to the development of this statistical milestone.

2 Current status of natural capital measurement at Statistics Canada

Statistics Canada's environmental statistics mandate is to collect, develop, compile, analyze and publish data on the environment, emphasizing their integration with socio-economic data. The agency's objective is to provide users in government, business and the public at large with consistent, comprehensive, timely and relevant statistics with which to study the relationship between the environment and human activity. It carries out this mandate through two principal activities.

First, the agency produces a series of **core environmental statistics** that are released on a regular basis. These have been produced for varying lengths of time, from just a few years to more than a decade. They are either in the form of **environmental accounts** integrated with economic data from the national accounts or in the form of **environmental survey** results.

Second, the agency produces **special studies** on a variety of topics. These are sometimes the result of research and development activities that may lead eventually to the creation of new core data products. In other cases, they are carried out to address a specific need (such as a request from another federal department for a survey on a particular topic). Most often, though, they are simply an outlet for analysis of results from core data products.

The current status of both the core data products and special studies is summarized in the remainder of this section (additional details are provided in Annex 1). Gaps and analytical opportunities related to them are discussed in Section 3.

2.1 Core statistics relevant to natural capital: **Environmental accounts**

Environmental accounts are distinguished from environmental surveys in several important ways. First, environmental accounts are, to the greatest extent possible, compatible with the economic data of the *System of National Accounts*, making them particularly useful for researchers who want to combine environmental and economic data. Second, environmental accounts are comprehensive in their coverage; that is, they account for all stocks or flows, as the case may be, of a given type. Third, environmental accounts are conceptually and methodologically coherent from one to another so that meaningful comparisons can be made between accounts.

The analytical benefits of environmental accounts are significant: ease of combination with economic data, comprehensiveness and consistent time series make them ideal for those who want to do detailed analysis of the link between the economy and the environment. This structure comes at a cost however. The data requirements to build environmental accounts are significant and, therefore, their scope of coverage is relatively limited.

Environmental surveys, on the other hand, are less demanding in terms of coverage and coherence. This makes them more flexible and applicable to a wider range of issues. It is not surprising, then, that Statistics Canada's suite of environmental accounts is more wide ranging than its environmental accounts.

Statistics Canada's core environmental accounts describe:

- the size of Canada's **natural resource assets** and their contribution to national wealth
- the **flows of materials and energy** between the environment and the economy.

2.1.1 Natural Resource Asset Accounts

The annual *Natural Resource Asset Accounts*[8] measure quantities of key commercial natural resources *in situ* and the annual changes in these assets due to natural processes and human activity. The accounts are

[8] Until recently, the *Natural Resource Asset Accounts* were known as the *Natural Resource Stock Accounts*. They were renamed to ensure consistency with international terminology.

designed to be consistent with the international guidelines for natural resource asset accounting in the UN *System of Environmental-Economic Accounts*.

The *Natural Resource Asset Accounts*, which are recorded using both physical and monetary units, form the basis of the estimates of Canada's natural resource wealth that are included in the *National Balance Sheet Accounts*.[9]

The natural resources currently measured include:

- **Metallic and non-metallic minerals**: iron, uranium, copper, gold, lead, molybdenum, nickel, silver, zinc, sulphur and potash
- **Fossil fuels**: conventional crude oil, oil sands, conventional natural gas and natural gas liquids, bituminous, sub-bituminous and lignite coal
- **Timber**: Commercial timber stocks in accessible, non-reserved forest areas
- **Land**: Agricultural land and built-up land.

2.1.2 Physical Flow Accounts

The annual *Physical Flow Accounts*[10] provide detailed measures of the flows of material and energy within the economy and between the economy and the environment. There are currently three sub-accounts:

- greenhouse gas emissions
- energy use
- water use.

The accounts describe flows in considerable detail, with estimates for each of 111 different industries (including public administration) and for households. They are also comprehensive, accounting for all flows of greenhouse gases, energy and water between the economy and the environment. Statistics Canada calculates several derived economy-environment variables from the accounts, including the direct and indirect intensity of flows[11] and estimates of material and energy flows for categories of final demand.[12]

Unlike the *Natural Resource Asset Accounts*, the *Physical Flow Accounts* are produced only in physical units of measure.

2.2 Core statistics relevant to natural capital: **Environmental surveys**

Statistics Canada currently conducts ten surveys relevant to measuring natural capital (see below for descriptions). The surveys are directed at households, businesses and governments. They are conducted every second year with the exception of the *Farm Environmental Management Survey*, which is conducted once every five years following the *Census of Agriculture*. The results of the surveys are made available in reports that released on the Statistics Canada website and in the agency's electronic database, CANSIM.

2.2.1 Waste Management Industry Survey

The biennial *Waste Management Industry Survey*[13] gathers information at the provincial level on the generation and management of municipal, non-hazardous solid waste in Canada. It reports on the quantities of residential and non-residential solid waste collected by municipalities and private waste management

[9] In a first for a statistical agency, Statistics Canada published estimates of natural resource wealth as part of the quarterly *National Balance Sheet Account* in November 2015. That report is available here.
[10] Until recently, the *Physical Flow Accounts* were known as the *Material and Energy Flow Accounts*. They were renamed to ensure consistency with international terminology.
[11] Direct intensity is a measure of the materials or energy directly used or produced by an industry per unit of its economic output. Indirect intensity is a measure of the materials or energy embodied in the products purchased by an industry per unit of its economic output.
[12] Typically, material and energy flows are measured in terms of their production by an industry or household. Demand-based measures turn this on its head to look at flows from the perspective of the consumption activities that create the demand for that production.
[13] The Waste Management Industry Survey is actually two surveys, one directed at businesses providing waste management services and the other directed at municipalities offering these services.

companies. The data reveal the share of waste collected that is sent for recycling/composting versus that disposed of. In addition to data on waste quantities, the survey also reports on the financial and employment characteristics of companies, local governments and other public bodies involved in waste management.

2.2.2 Households and the Environment Survey

The biennial *Households and the Environment Survey* measures a variety of household behaviours that are relevant to the environment. The survey has a large sample size (approximately 32,000 households), which permits estimates to be prepared at the national, provincial, Census Metropolitan Area (large city) and, beginning with the 2013 reference year, Census Area levels.

The major themes covered by the *Households and the Environment Survey* are:

- energy use and home heating/cooling practices
- drinking water quality and consumption choices
- water conservation practices
- fertilizer and pesticide use
- recreational vehicles and gasoline-powered outdoor equipment
- indoor environmental quality
- composting
- management of household hazardous and electronic waste
- participation in nature-based activities
- environmentally conscious purchasing decisions.

2.2.3 Households and the Environment Survey: Energy Use Supplement

The *Households and the Environment: Energy Use Supplement* is a supplement to the *Households and Environment Survey* focused on collecting residential in-home energy use statistics. Respondents to the core Households and the Environment Survey are asked to provide Statistics Canada with the name of their energy suppliers and their account numbers. Energy suppliers then provide the energy use data for each account.

Like its parent survey, the energy use supplement is conducted every second year and is based on a large sample of households. The survey has been run only three times to date (2007, 2011 and 2013).

Every second iteration of the energy use supplement gathers more detailed information on the use of home heating equipment and fuels and well as participation in energy-saving activities. Funded by Natural Resources Canada it is conducted approximately every fourth year in conjunction with the Household Environment Survey.

The major themes covered by the Energy Use Supplement are:

- heating equipment and fuel choices
- household and dwelling characteristics
- household lighting choices
- energy-saving and retrofitting practices.

2.2.4 Survey of Environmental Goods and Services

The biennial *Survey of Environmental Goods and Services* produces national and provincial estimates of the production of “environmental” goods and services by industry. It replaced (beginning in 2008) the earlier *Environment Industry Survey*. The new survey has been conducted three times (2008, 2010 and 2012) but changes in the survey content and methodology limit the degree to which the results from the three cycles are comparable.

Environmental goods and services are those that are used, or can potentially be used, to measure, prevent, limit or correct environmental damage to water, air, soil as well as problems related to waste, noise and ecosystems. They also include clean or resource-efficient (eco-efficient) technologies that decrease material

inputs, reduce energy consumption, recover valuable by-products, reduce emissions and/or minimize waste disposal problems.

The survey covers the following categories of environmental goods and services:

- renewable energy production
- management of non-hazardous waste
- management of industrial air pollution or flue gas
- industrial wastewater treatment and municipal sewage treatment
- remediation of ground water, surface water and leachate
- remediation of soil, sediment and sludge
- site remediation services and environmental emergency response services.

Based on the feedback from survey users, Statistics Canada decided in 2015 to redesign the Survey of Environmental Goods and Services. The scope of environmental goods and services will be re-examined to take into account international developments in the measurement of revenue related to environmental goods and services. Furthermore, the survey will be designed to permit provincial-level estimates in addition to the current national estimates. Employment related to environmental goods and services will also be measured. The redesign will be complete in time for the 2017 reference year.

2.2.5 Survey of Environmental Protection Expenditures

The biennial *Survey of Environmental Protection Expenditures* gathers information at the national and provincial levels on the costs imposed on industry to meet Canadian and international environmental regulations, conventions or voluntary agreements. The survey measures the expenditures made by Canadian industry to comply with present or anticipated environmental regulations, conventions and voluntary agreements. The survey also collects information on environmental management practices and environmental technologies used by industry for the purpose of preventing, abating or controlling pollution.

The major themes covered by the *Survey of Environmental Protection Expenditures* are:

- capital and operating expenditures on environmental monitoring
  capital and operating expenditures on environmental assessments and audits
- capital and operating expenditures on reclamation and decommissioning
- capital and operating expenditures on wildlife and habitat protection
- capital and operating expenditures on waste management and sewerage services
- capital and operating expenditures on pollution abatement and control processes (end-of-pipe)
- capital and operating expenditures on pollution prevention processes
- capital and operating expenditures on renewable energy and on greenhouse gas emission mitigation
- operating expenditures on environmental fees, fines and licenses.

2.2.6 Industrial Water Survey

The biennial *Industrial Water Survey* gathers information at the national and provincial levels on the volume of water brought into the facilities in the mining, thermal power and manufacturing industries, including information on the source, purpose, treatment and possible re-circulation of this water. Data are also collected on the volumes of wastewater treated and discharged and on the cost of intake and discharge. In addition to the national and provincial levels, the survey is also designed to produce results for major drainage regions, reflecting the fact that water flows do not respect political boundaries.

The major themes covered by the *Industrial Water Survey* are:

- water use by source, type and purpose (intake, recirculation, discharge, consumption)
- treatment of intake and discharge water
- costs of water acquisition, treatment and discharge.

2.2.7 Agricultural Water Survey

The biennial *Agricultural Water Survey* gathers information at the national and provincial levels on water use, irrigation methods and practices, and sources and quality of water used for agricultural purposes on Canadian farms. In addition to the national and provincial levels, the survey is also designed to produce results for major drainage regions, reflecting the fact that water flows do not respect political boundaries.

The major themes covered by the *Agricultural Water Survey* are:

- water use by source, type and purpose (intake, recirculation, discharge, consumption)
- treatment of intake and discharge water
- costs of water acquisition, treatment and discharge.

2.2.8 Survey of Drinking Water Plants

The biennial *Survey of Drinking Water Plants* gathers national and provincial level data related to the production of municipal drinking water. The survey is a census of drinking water plants serving more than 300 people. It gathers for information on volumes of water drawn and treated, treatment type, financial aspects of the operation, as well as source and treated water quality. In addition to the national and provincial levels, the survey is also designed to produce results for major drainage regions, reflecting the fact that water flows do not respect political boundaries.

The major themes covered by the *Survey of Drinking Water Plants* are:

- source water quality
- potable water production and use by sector
- population served
- water treatment methods
- capital and operating expenditures.

2.2.9 Farm Environmental Management Survey

The *Farm Environmental Management Survey,*[14] which is conducted every five years following the *Census of Agriculture* and funded by Agriculture and Agri-Food Canada gathers data at the national and provincial levels on farming practices on Canadian crop and livestock operations. The survey focuses on information related to manure storage and spreading, pesticide application, crop and nutrient management, grazing and the implementation of environmental farm plans.

The major themes covered by the *Farm Environmental Management Survey* are:

- environmental farm plans
- management practices
- wetlands and waterways
- grazing practices
- pesticide use.

2.3 Core statistics relevant to natural capital: **Special studies**

Statistics Canada has produced many special studies over the history of its environment statistics program. What is covered here is a sample of some of the more recent studies that are of particular relevance to measuring natural capital.

[14] Beginning with the 2017 cycle, this survey will be known as the Farm Management Survey. In addition to its traditional focus on environmental management practices, the survey will begin collecting data on use of innovative technologies on farms.

2.3.1 Hazardous Waste Management Industry Survey

The one-time *Hazardous Waste Management Survey 2012* gathered data on the amount of hazardous waste handled by the hazardous waste management industry. It covered hazardous wastes accepted at transfer stations, intermediate processing facilities and final hazardous waste treatment and disposal/recycling facilities. The survey was funded by Environment Canada. At the moment, Environment Canada is considering whether to fund further cycles of the survey.

2.3.2 Water Asset Account

In 2010, Statistics Canada published a detailed report on water in Canada that included its first effort at measuring Canada's renewable water assets (in Section 2). To measure these assets, the study used a concept known as water yield that relates to the amount of water flowing in the nation's network of streams, rivers and lakes. A portion of this water originates from groundwater as it flows back to the surface and from melting glaciers. However, most of it is created when rain and melted snow flow over the ground, eventually reaching a surface water body.

Statistics Canada is currently working toward regular production of a water asset account based on the concepts and methods developed through this research.

2.3.3 Trends in climate-related variables

Between 2010 and 2012, Statistics Canada released five studies focused on trends in key climatic variables:

- glacier mass balance
- temperature
- precipitation
- sea ice
- snow cover.

The studies presented data related to Canada's climate and the impacts of climate change using short statistical analyses of climate-related data. The series was a result of collaboration between Statistics Canada, Environment Canada and Natural Resources Canada intended to make data related to Canada's climate easily and regularly accessible. The collaboration leveraged Statistics Canada effective and well-known data dissemination channels.

Though the intention at the time was that the analyses would be repeated periodically and that additional variables would be added over time, there have been no updates to the series since the final study was published in April 2012.

2.3.4 Ecosystem accounts

Statistics Canada published a groundbreaking report on ecosystem accounting in 2013. It represented the first effort at a comprehensive accounting for ecosystems published by a statistical agency anywhere in the world. The study was conducted with special funding from Policy Horizons Canada as a collaborative effort between several partner federal departments: Statistics Canada and Environment Canada as co-leads along with 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.

The study covered the following major themes:

- land cover change,
- human modification of natural landscapes,
- ecosystem services in the boreal forest,
- biomass extraction from key ecosystems,
- marine and coastal ecosystem goods and services,
- freshwater and wetland ecosystem goods and services, and

- ecosystem goods and services in the Thousand Islands National Park.

Though Statistics Canada has no current plans to undertake another comprehensive assessment of ecosystem assets, specific elements of the research are being pursued, specifically, the further development of accounts for freshwater ecosystems. Importantly, the interdepartmental working group created to carry out the project has remained in place and active since the study was published.

2.3.5 Natural Resource Reserve Index

In 2009, Statistics Canada published a study containing a methodology and initial results for a natural resource reserve index. This was the first time that such an index had been published by a statistical agency. Its goal was to overcome the difficulty of assessing the overall sustainability of Canada's key natural resources (fossil fuels, minerals and timber) posed by the fact that it is not possible to simply add up the physical extent of different resource reserves to determine whether they are being used sustainably over time. Nor is the sum of the monetary value of these reserves (that is, resource wealth) an indication of their physical sustainability, since prices are influenced by a number of factors beyond the size of the underlying stocks. To address this problem, Statistics Canada proposed a volume index of natural resource reserves. Analogous to a price index but turned on its head, this index was constructed using the share of each resource in resource wealth in a base year to weight the physical measures of the reserves, allowing them to be added together into an index with a value of 100 in the base year.

3 Gaps and analytical opportunities

Statistics Canada's environmental statistics program is one of the most complete in the world and the agency does an excellent job providing users with analysis of its findings. This said, many possibilities to build upon the program's success can be imagined.

As noted in the introduction, the environmental statistics program is very small compared to its economic and social statistics cousins. With limited resources, it is to be expected that substantial gaps exist between what is currently measured and what would be measured in a truly complete program. The same can be said for analysis: only a handful of the analytical opportunities afforded by the data are (and can reasonably be) exploited by Statistics Canada.

In what follows, we identify the major gaps in the program today and discuss some of the analytical opportunities that might be leveraged, either by Statistic Canada or by external researchers. We start by talking about two major analytical opportunities that would exploit essentially all the data produced by the program.

In the following section, the opportunities presented here are prioritized into a proposed research agenda.

3.1 Major analytical opportunities: Measuring *Trends in Natural Capital* and *Green Growth* in Canada

3.1.1 Natural capital trends in Canada – Time for a comprehensive review?

Until 1996, Environment Canada reported periodically on the state of the environment in Canada. Major reports of this sort were produced in 1986 (Bird and Rapport, 1986), 1991 (Government of Canada, 1991) and 1996 (Environment Canada, 1996). Since 1996, no comprehensive portrait of Canada's environment has been produced.[15] Rather, Environment Canada has employed a variety of indicator-based approaches to reporting on the state of the environment. These efforts eventually evolved into today's *Canadian Environmental Sustainability Indicators* program. While valuable in many ways, not least for its regular data updates, excellent metadata and ease of access, this program lacks the breadth of former state of the environment reports. It provides no information about energy production or use, for example, in spite of the important role energy plays in determining environmental quality.

For its part, Statistics Canada has also abandoned its former efforts at comprehensive statistical portraits of the environment. As noted in the Introduction, Statistics Canada's environmental compendium *Human Activity and the Environment* switched from a five-yearly cycle to an annual cycle in the early 2000s. The benefit of this change was more frequent releases. The cost, however, came in comprehensiveness. Whereas the versions of *Human Activity and the Environment* produced between 1979 and 2000 all aimed at full coverage of the environment and human interaction with it, the annual compendia that began in 2003 are all thematically focused. Each annual edition treats only one issue (for example, water, energy, or land-use in urban areas). Though its treatment of the issues is comprehensive, this approach naturally falls short of a complete portrait of the state of the environment.

This raises the question whether Canadians are well served by the evolution in reporting on the state of the environment. Is today's less comprehensive but more frequent approach to reporting on the environment an improvement over the past? Or is the "whole is greater than the sum of the parts" view provided by the old approach to state of the environment reporting something to be desired again?

On balance, it would seem reasonable to at least explore the options for reviving the old approach - but with the advances of the intervening 20 years taken fully into account. One such advance is simply the emergence of the natural capital framework as a robust guide to understanding the environment and human interaction

[15] The closest thing to a comprehensive state of the environment report produced in recent years was the excellent *Ecosystem Status and Trends Report* released by the federal, provincial and territorial governments in 2010 (Federal, Provincial and Territorial Governments of Canada, 2010). While comprehensive in terms of its treatment of ecosystem quality, this report did not have the breadth of earlier state of the environment reports. In particular, it did not cover the demands placed on the environment by human activities or the efforts to mitigate those demands to the same extent.

with it. State of the environment reports of old lacked an overall conceptual framework, potentially leaving readers with a sense that they were somewhat *ad hoc* and largely data driven. This was not helped by the fact that the content and style of the reports changed greatly over time, giving the impression that state of the environment reporting was as much art as science. With the emergence of the natural capital framework, this need no longer be the case. The framework defines clearly what should be measured with respect to the environment and human interaction with it. Using the framework to underpin a new report on trends in natural capital would ensure that it did not appear *ad hoc* in any way.

Another obvious advancement in the last 20 years is the Internet. It is possible today to disseminate very large volumes of data and analysis in easy-to-navigate and easy-to-maintain on-line structures. This was simply not possible when the last state of the environment reports were produced. The resulting high cost of producing hardcopy reports and managing the underlying databases was, in fact, one of the main reasons for their demise.

The last advancement is the data describing natural capital themselves. Since the mid-1990s, Statistics Canada's holdings of environmental statistics have increased substantially. So too have the data holdings of other federal departments and their provincial/territorial counterparts. So, even if our understanding of natural capital remains incomplete, it is much better than it was 20 years ago. For this reason, if for no other, now would seem an appropriate time to consider a comprehensive assessment of the trends in natural capital and the factors that affect it in Canada.

It is also worth noting that the need for a comprehensive analysis of natural capital is now greater than ever. Natural capital is increasingly at risk from over-exploitation, climate extremes and changing land uses among other pressures. At the same time, the understanding of the importance of natural capital to well-being and sustainability is creating new demands for data to help guide policy.

3.1.2 Green Growth in Canada

Governments in Canada[16] and around the world increasingly view the need to preserve and enhance natural capital as a potential source of economic growth. The OECD, among other multilateral organizations, has picked up on this and launched a major initiative to support what it calls "green growth" in its member countries.

The OECD's initiative is unique in several ways. For one, it is both a policy initiative and a complementary statistical initiative. It is rare to see policy development in any field occur in parallel with statistical development. It is much more usual to see policy developed and adopted before real consideration is given to the need for supporting statistical information. By that time, it is often too late to get the proper data. The OECD wisely avoided this pitfall by designing the two together; the strategy has both a set of policy recommendations and a set of statistical indicators to support it.

The second unique element of the approach is that the statistical half of the initiative has its own clear and explicit conceptual framework: the natural capital framework (Organisation for Economic Co-operation and Development, 2011, p. 9). Again, it is rare, especially in the field of environmental statistics, for a statistical exercise to be so explicit about its underlying conceptual framework. It is worth noting that this is the same conceptual framework that Statistics Canada has recently chosen to underpin its environmental statistics program.

The final unique element of the approach is that the statistical half of the initiative has an equally clear and explicit measurement framework: The UN *System of Environmental-Economic Accounting - Central Framework*. Again, this same framework underpins Statistics Canada's environmental accounts.

The fact that green growth is of policy interest in Canada and that the OECD has identified a well-founded set of indicators (see the appendix) to measure it – indicators that are fully coherent with Statistics Canada's environmental statistics – suggests that compiling green growth indicators for Canada is a significant analytical opportunity. Statistics Netherlands has already produced two such reports for the Netherlands with interesting

[16] In Canada, the provinces of Quebec, Ontario and British Columbia all have major policy initiatives related to promotion of the so-called "clean-tech" sector. At the federal level, Sustainable Development Technology Canada provides significant funding to firms operating in the sector who have products ready for commercialization.

results (Statistics Netherlands, 2011 and 2013). The OECD is slowly building up a database of green growth indicators for all its member states but it has not yet completed its work. This leaves room for a stand-alone Canadian report to be compiled. Canadian data exist or could be compiled relatively easily for the majority of the OECD indicators, meaning that the report would be of real analytical value.

3.2 Environmental Accounts – Gaps and analytical opportunities

3.2.1 Natural Resource Asset Accounts

Gaps in the Natural Resource Asset Accounts

As they exist, the *Natural Resource Asset Accounts* are reasonably complete. The main missing/incomplete elements are described below.

- **Physical Timber Asset Account** – Statistics Canada has not updated the Physical Timber Stock since 2003 due to changes in the underlying forest inventory data. The account rests upon a computer model that simulates the growth of the forest over time to estimate the standing area and volume of forest each year. The model was calibrated using data from the Canadian Forest Inventory. This inventory was replaced with the National Forest Inventory in the early 2000s and the model has not been recalibrated to work with the newer inventory. As a result, there is no annual time series of Canada's forest area and volume. Natural Resources Canada does publish a static picture of forest area and volume in its State of Canada's Forests Report, noting that both volume and area are "expected" to remain relatively stable in the future. Updating Statistics Canada's account to provide an annual assessment of timber stocks would be superior to this.

- **Marine Resource Asset Account** – Statistics Canada has never compiled a physical marine resource asset account because of irregularity of stock assessments for commercial species by Fisheries and Oceans Canada. Natural capital accounts require regular input data to meet the objective of providing a consistent and comprehensive portrait of the trends in natural capital assets. In the case of marine species, such data are not available. While Fisheries and Oceans Canada has an on-going program of assessing commercial marine stocks, not every stock is assessed every year. Rather, stocks are assessed only periodically when there is a call for an assessment from a fishery manager or when stock assessment scientists feel one is warranted. Working with these data to produce an annual, comprehensive marine asset account would be challenging but would fill an important gap in the understanding of our natural capital would justify the effort.

  As for a monetary marine resource asset account, part of the reason for it never having been developed is simply that its precursor – the physical account – has not proven possible. Beyond that, a monetary account faces its own significant challenges of data availability. Specifically, the required data on the costs of fish harvesting are not collected on a regular or comprehensive basis by the Department of Fisheries and Oceans. The *Costs and Earnings Survey* was last conducted in 2004 and covered only Canada's East coast fisheries. Again, though it would be challenging to compile a monetary asset account faced with these data limitations, knowing the wealth associated with Canada's marine resources would help complete the picture of natural resource wealth currently offered by the *Natural Resource Asset Accounts*.

- **Water Resource Stock Account** – Until today, Statistics Canada's only effort at compiling a physical account for water resources was the research effort noted above in Section 2.3.2. A decision was recently taken to produce a regular Water Resource Stock Account, beginning in spring of 2016

  The next logical step would be to compile a monetary water asset account. Doing so for all water resources in the country would be complex given the varied services that water provides to the economy. Though a comprehensive monetary account is likely not feasible for now, a more limited one focused only on commercial uses of water could be completed with sufficient investment. A sensible starting place for such an account would be to place a value on the water used by the largest

commercial consumers: agriculture, the electric power industry (hydro and thermal), primary metal manufacturing, water treatment, the pulp and paper industry, the chemical industry, the food industry and the mining/oil and gas industry. Developing methodologies and data sources necessary to compile estimates of the value of water to these industries would be a significant challenge. But, again, being able to add the value of water to the other assets in the Natural Resource Asset Accounts would justify the effort

- **Land Account** – Statistics Canada has one of the oldest and most comprehensive physical land accounting programs of any statistical agency. It was this program that served as the foundation for the experimental work on ecosystem accounting that was described in Section 2.3.4. The major shortcoming of this work until now was that the data were not updated frequently and that not all parts of the account are updated at the same time. This will be corrected in 2016 when Statistics Canada begins publishing an annual land cover/land use account. The new account will permit the publication of land cover maps for each Census Metropolitan Area similar to this this one for Toronto.

  In monetary terms, all of Canada's commercial land (farmland and built-up land) is already regularly measured as part of Statistics Canada's traditional national accounts. These are the values currently used in the environmental accounting program as the value of land. Beyond this, the only effort at measuring the value of other land areas is the tentative first effort at valuing ecosystem services in the Thousand Islands National Park described in Section 2.3.4. Extending this effort to cover all ecosystem services for all land is likely not feasible now. A more limited effort at, for example, valuing a given ecosystem service that is closely related to commercial activity in a specific sector might be possible however. One example would be the contribution of forestland to soil erosion control along salmon spawning streams. Another might be the contribution of prairie wetlands to flood protection for farmers.

Analytical opportunities related to the Natural Resource Asset Accounts

Though incomplete in their current form, the Natural Resource Asset Accounts offer several analytical opportunities that are not currently being exploited by Statistics Canada.

- **Natural Resource Reserve Index** – The natural resource reserve index that was described in Section 2.3.5 was produced just once in a research study by Statistics Canada. Given the utility of the index as a means of assessing the overall sustainability of natural capital use, it would seem a good candidate for regular production. In fact, the OECD considers this to be such an important indicator that it selected it as one of its six "headline" indicators of green growth. Statistics Canada was well ahead of any other statistical agency in studying this indicator in 2007.

- **Assess the distribution of natural resource wealth** – Starting in December 2015, Statistics Canada began measuring natural resource wealth on a quarterly basis and including those measures in the National Balance Sheet Account, which portrays the ownership of assets by sector. This allows, for the first time in any country, an assessment of the distribution of natural resource wealth between the private and public sectors. Though governments, on behalf of Canadians, are the legal owners of most natural resources in Canada, the corporations that are licensed by governments to exploit those resources are their effective economic owners. This is reflected in the fact that governments do not collect all of the resource rent associated with resource exploitation but leave a considerable share to be collected by corporations and their shareholders.[17] With the new quarterly resource wealth estimates, an assessment of this split will be possible.

- **Measure multifactor productivity including natural capital** – Statistics Canada produces Canada's official estimates of multifactor productivity. As in all countries, these estimates consider only labour, produced capital and materials/services as factors of production. This ignores the important role that natural capital plays as a factor of production, especially in a resource dependent country like Canada.

[17] Resource rent is the return that natural resource companies return on their investments that is over and above the "normal" return that would be expected in the market. These extra returns reflect the fact that a major input into their production functions – the resources themselves – are provided for free by nature.

The inclusion of natural capital in Canada's measures of multifactor productivity could well show that Canada's productivity performance in recent decades has not been as weak as it is often said to be. Like the natural resource reserve index, multifactor productivity including natural capital is considered by the OECD to be an important indicator of green growth.[18]

3.2.2 Physical Flow Accounts

Gaps in the Physical Flow Accounts

The *Physical Flow Accounts* are substantially incomplete in their current form. The main missing elements are accounts for:

- **Air pollutants other than greenhouse gases** – At the moment, the only pollutants measured in the *Physical Flow Accounts* are greenhouse gases.[19] This ignores the many other pollutants that are emitted to the atmosphere from economic activity. A logical place to begin filling this gap would be with the inclusion of emissions of the so-called criteria air contaminants.[20] Environment Canada produces annual data on the emissions of these gases that are suitable for inclusion in the *Physical Flow Accounts*.

- **Non-hazardous solid wastes** – Comprehensive national and provincial data on the disposal of non-hazardous solid wastes are available from Statistics Canada's *Waste Management Industry Survey*, though the survey does not provide detailed information on the source of the waste. The *Physical Flow Accounts* are intended to measure flows at their point of origin, so a means of attributing municipal solid wastes back to their source would be required to adapt this survey to meet the needs of this account.

- **Sewage** – No comprehensive national data source on sewage emissions exists, though Environment Canada's *National Pollutant Release Inventory* provides data on some of the constituents of sewage from large wastewater treatment plants. As with non-hazardous solid wastes, a means of attributing the flows of sewage back to their source would be required to adapt this survey to meet the needs of this account. In addition, sources of data for emissions from smaller treatment plants and from emitters that do not send their wastewater to external treatment plants (for example, households on septic systems and industrial facilities that manage their own wastewater) would be required.

- **Hazardous wastes** (liquid, solid and gaseous) – No comprehensive national data source on hazardous wastes exists, though the *National Pollutant Release Inventory* provides data on emissions of a range of hazardous wastes from large point-source industrial emitters. These data are appropriate for inclusion in the *Physical Flow Accounts* in that they do identify the source of the flow. However, they would have to be complemented with a data source for emissions from smaller emitters and from industries (such as agriculture, mining and petroleum extraction) that are not covered by the *National Pollutant Release Inventory*.

- **Nutrients** – The points made above regarding hazardous wastes apply to nutrients as well.

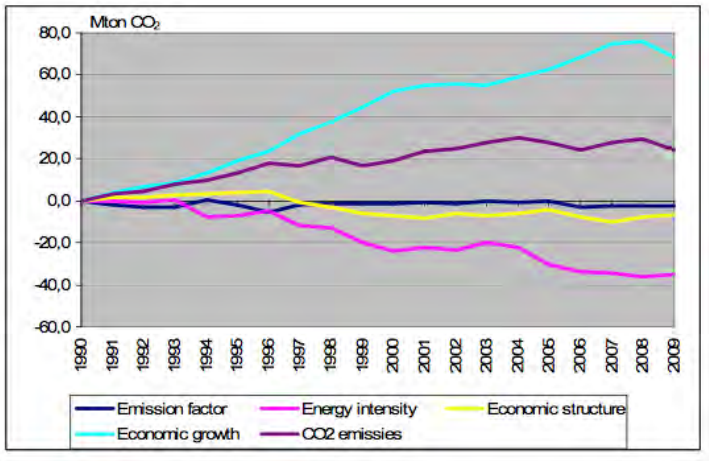
Analytical opportunities related to the *Physical Flow Accounts*

- **Studying the drivers of decoupling** – Sustainability requires that goods and services be produced as efficiently as possible in terms of materials and energy use. The *Physical Flow Accounts* are uniquely suited to measuring this. Ratios of output per unit of material or energy input (or, conversely, material/energy input per unit of output) can be readily calculated for individual industries, groups of industries or the economy as a whole. Trends in these ratios are a function of several factors: actual increases in efficiency of material and energy use, economic growth, shifts in economic structure, shifts

[18] The Sustainable Prosperity project of which this report is part is focused on promoting measurement of multifactor productivity including natural capital.
[19] Strictly speaking, the greenhouse gas data are not complete either, since they include emissions only of carbon dioxide, methane and nitrous oxide, leaving out gases that are emitted in smaller quantities such as sulfur hexafluoride and hydrochlorofluorocarbons.
[20] Sulfur oxides, nitrogen oxides, particulate matter, volatile organic compounds, carbon monoxide, ammonia and ground-level ozone.

in material inputs and so on. Using a technique known as decomposition analysis, the *Material and Energy Accounts* can be used to analyse the impact that these different factors have in determining the trends in energy and material use. An example of this kind of analysis from Statistics Netherlands is shown below. Using decomposition analysis, the main factor determining the change in Dutch carbon dioxide emissions between 1990 and 2009 was found to be economic growth (turquoise line). Increased energy efficiency (pink line) and structural changes (yellow line) played a role in limiting emissions but their impact was not enough to offset that of increased economic output. As a result, emissions grew by more than 20 megatonnes over the period. Had energy intensity and economic structure remained as they were in 1990, however, total emissions would have been 35% higher than they were (Statistics Netherlands, 2010, p. 22).

Figure 1 - Decomposition of Changes in Dutch Carbon Dioxide Emissions, 1990 to 2009



3.2.3 Other gaps and opportunities related to Statistics Canada's environmental accounts

Environmental activity accounts

While Statistics Canada is a world leader in accounting for natural resource assets and material and energy flows, there are elements of environmental accounting that the agency has not yet tackled.

The UN System of Environmental-Economic Accounting Central Framework (SEEA-CF) is the international standard for environmental accounts. It sets out what is considered a complete set of accounts (with the exception of ecosystem accounts, which are still considered experimental and therefore are not part of the international standard – see the next point below). The principal components of the SEEA-CF are:

- physical flow accounts
- environmental activity accounts (no equivalent at Statistics Canada)
- asset accounts.

Of the three principal components, Statistics Canada has no equivalent to the environmental activity accounts. These accounts are intended to record transactions in monetary terms within the economy that may be considered environmental in nature. Generally, these transactions concern activity undertaken to preserve and protect the environment; for example, spending on pollution abatement equipment or remediation of contaminated sites. Further, there are a range of transactions, such as environmental taxes and subsidies, that reflect efforts by governments to influence the behaviour of producers and consumers with respect to the environment.

Most of these environmental transactions are implicitly recorded in the traditional national accounts framework but are "invisible" because the structure of the accounts does not reveal them explicitly. For example, investments in pollution control equipment are measured along with other investment flows but are not

reported separately from them. The SEEA-CF environmental activity accounts provide guidance on making these transactions explicit.

The principal goal of the environmental activity accounts is to reveal the environment-related transactions that are currently invisible within the traditional national accounts. Further, when combined with data from the Physical Flow Accounts, information on these transactions may help assess whether economic resources are being used effectively to reduce pressures on natural capital.[21]

Statistics Canada experimented with the compilation of one type of environmental activity account in the 1990s. The *Environmental Protection Expenditure Accounts* tracked business and government spending on capital and maintenance expenditures devoted to environmental protection. The accounts were not continued because of difficulty in obtaining the necessary data from municipal governments, whose financial systems were not structured to maintain the level of detail needed to populate the accounts. The *Survey of Environmental Protection Expenditures* described in Section 2.2.5 continues to collect much of the data required to compile the business sector portion of an environmental expenditure account.

In addition to environmental protection expenditure accounts, the SEEA-CF includes guidance on two other types of environmental activity accounts: accounts for producers of environmental goods and services and accounts for environmental taxes, subsidies and other environment-related payments.

Environmental goods and services are those produced for the explicit purpose of environmental protection. They may be produced by any industry in the economy since they are defined by the use to which they are put rather than by their inherent characteristics. Thus, a pump manufacturer would be considered to produce an environmental good if one of its pumps were used in a wastewater treatment facility. This poses a number of measurement challenges, from identifying all the potential producers of environmental goods and services to determine what share of their output is environmental in nature. These challenges mean that reliable data on environmental goods and services are not easily collected. Statistics Canada has long run a survey in this area (the *Survey of Environmental Goods and Services* – see Section 2.2.4) that has proven difficult to design. As a result, methodological changes have been frequently introduced and no fully comparable time series of data has ever emerged. For this reason, the survey has never been used to compile an environmental goods and services account. Policy interest in this area is increasing, however, so now might be an appropriate time to reconsider this. Governments in Quebec, Ontario and British Columbia all have major strategies to support businesses producing environmental goods and services. In addition, every province except New Brunswick and Prince Edward Island has an industry association focused on the same goal.

Like environmental goods and services, defining and measuring environmental payments is not simple.[22] To date, Statistics Canada has not collected the basic statistics required to compile an account of environmental payments. Other organizations, including Sustainable Prosperity (Arros, 2015) and the International Institute for Sustainable Development (EnviroEconomics, 2010), have looked at the issues of environmental taxes and subsidies in some detail. Interest in the issue is growing along with increasing calls for the use of taxation to achieve environmental goals (such as carbon taxes) and for the leveling of the playing field for renewable energy resources. Again, now may be an appropriate time for Statistics Canada to reconsider the compilation of an environmental payments account.

Ecosystem accounts

Ecosystem accounts are not a complete gap in Statistics Canada's environmental accounts, since the agency has conducted groundbreaking research in this area (see Section 2.3.4). At the moment, the agency has no plans to carry out the large-scale effort that would be required to compile a complete ecosystem account.[23] It does, however, have plans to pursue work on specific aspects of ecosystem accounting where it has built up the required data and expertise.

[21] While in principle, this kind of analysis is possible, in practice it can be difficult to definitively identify cause and effect.
[22] See Sustainable Prosperity's work on this topic for an excellent overview of the challenges (Arros, 2015).
[23] This is consistent with the still exploratory nature of work in this field. The UN SEEA continues to see ecosystem accounting as an experimental effort, so any agency wanting to compile a comprehensive account would be faced with a number of unresolved conceptual and methodological issues.

3.3 Environmental surveys – Gaps and analytical opportunities

3.3.1 Waste Management Industry Survey

Gaps

The *Waste Management Industry Survey* (see Section 2.2.1) offers comprehensive data on solid waste flows in its current form. The main concern with its coverage is the fact that it runs only every second year, meaning that analysts are not provided with data that are as timely or frequent as they could be.

Analytical Opportunities

The main analytical opportunity rests in using the survey as the basis for creating a material flow account for non-hazardous solid waste (see Section **Error! Reference source not found.**). With such an account, it would e possible to carry out the kinds of analysis that integration of data into the *Input-Output Accounts* framework permits: resource productivity/efficiency; decomposition analysis; demand-based flows. Creation of such an account would require attribution of the solid waste flows to their source, something that the survey does not currently do.

3.3.2 Households and the Environment Survey

Gaps

There are no significant gaps in the *Households and the Environment Survey* (see Section 2.2.2). The only concern in this regard is the fact that it runs only every second year, meaning that analysts are not provided with data that are as timely or frequent as they could be.

Analytical Opportunities

The main unexploited analytical opportunity related to this survey lies in paying greater attention to the data at the municipal level. Statistics Canada largely restricts its analysis to results at the national and provincial levels. Since the survey has such a large sample size (32 thousand households), it also produces robust data at the level of census metropolitan areas (large cities). Relatively little attention has been paid to those data, in spite of the fact that many household behaviours (recycling and composting, for example) are a function of municipal rather than national or provincial policies. One interesting possibility would be an index ranking large cities in terms of the pro-environment behaviours of their citizens.

3.3.3 Households and the Environment Survey: Energy Use Supplement

Gaps

There are no significant gaps in the *Households and the Environment Survey: Energy Use Supplement* (see Section 2.2.3). The only concern in this regard is the fact that it runs only every second year, meaning that analysts are not provided with data that are as timely or frequent as they could be.

The other concern with the scope of this survey is that in-home energy use represents just part of households' demand for energy. Vehicle use is the other half of this portrait and it is one that is currently not well understood. Statistics Canada's main energy statistics report, the *Report on Energy Supply and Demand*, does not provide a clear measure of private vehicle energy consumption. Rather, it measures something called "retail pump sales", which is a measure of all gasoline and diesel fuel sold at retail outlets, regardless of who it is sold to. The *Physical Flow Accounts* do provide an estimate of household consumption of motor fuels, but it is not broken down by type of fuel and it is not based on directly observed data.[24]

Statistics Canada did invest in a new survey to collect private vehicle motor fuel use directly in the mid-2000s. The survey was cancelled after two iterations as a cost cutting measure, however, and has not been reinstated. Reinstating this survey would be timely given the increasing importance of understanding energy use in the face of a possible tax or cap on carbon emissions in the near future.

[24] The estimate is derived by applying a unit price for motor fuels to the monetary estimate of motor fuel consumption that comes from the Input-output Accounts.

Energy use is an important element of households' demands on natural capital. But it is not the only one. Water use and emissions of liquid, solid and gaseous wastes are all household flows that place substantial burdens on natural capital. None of these is currently measured by the *Households and the Environment Survey* supplement, but water use, at least, could be. Measuring solid, liquid or gaseous waste emissions, on the other hand, is not likely possible as a supplement to the *Households and the Environment Survey* because households have no simple way of keeping track of these flows. Water use could be measured by referencing household water utility account information; this is the methodology that is used successfully to measure energy use.[25]

Analytical Opportunities

An unexploited analytical opportunity with the Energy Use Supplement is development of a regression model that correlates energy use with the household characteristics collected through the survey, including income, level of education, age of dwelling, ownership status, type of dwelling, type of heating equipment and type of thermostat. Such a model would be useful in predicting future energy use based on different scenarios about the evolution of the housing stock and the economy.

3.3.4 Survey of Environmental Protection Expenditures

Gaps

The *Survey of Environmental Protection Expenditures* (see Section 2.2.5) is comprehensive with respect to the expenditures it measures. It is not comprehensive in terms of industrial scope however, as the agriculture, construction, transportation and service industries are not covered. The government and household sectors are also not covered, even though they both make significant expenditures for environmental protection. Collecting data for these missing sectors would provide a more complete portrait of societal efforts to protect natural capital. Of the missing sectors, expenditures by governments are likely to be the most significant so any effort to extend the coverage of the survey would best start there.

Analytical Opportunities

In principle, there is a relationship between environmental protection expenditures and the burden placed on natural capital. As expenditures go up, presumably emissions of pollutants and use of raw materials should decline. The empirical relationship between expenditures and natural capital burdens has not been the subject of much investigation however. If data from the *Survey of Environmental Protection Expenditures* could be linked with data from, say, the *National Pollutant Release Inventory*, this relationship could be studied. The results of such an analysis could provide a measure of the economic efficiency of regulatory efforts by looking at the reductions in burden per unit of expenditure.

3.3.5 Industrial Water Survey

Gaps

The *Industrial Water Survey* (see Section 2.2.6) is comprehensive with respect to the water flows it measures but is not in terms of industrial scope. Important industries are missing from the survey universe, most notably, the oil and gas extraction industry, the hydroelectric power industry and the service industries. Agriculture, governments and households are also not covered but these are all the targets of other of Statistics Canada's water surveys. Expansion of the *Industrial Water Survey* to cover the oil and gas extraction industry is arguably the most serious gap given the contentious nature of this industry and concerns over its impacts on natural capital. Extension of coverage to the hydroelectric power industry would also be valuable given the impact that this industry has had on reshaping water flows in Canada.

Analytical Opportunities

The main analytical opportunity related to the *Industrial Water Survey* lies in combining results from it with those from Statistics Canada's other surveys of water use in agriculture (Section 3.3.6) and drinking water plants (Section 2.2.8) to prepare a regular assessment of reliance on water resources by purpose and drainage basin and compare this with water availability. Statistics Canada has already produced such an

[25] Energy use is measured by consulting household energy utility accounts.

analysis once in the 2010 edition of the report *Human Activity and the Environment*. It showed that some drainage regions, especially those in the Prairies and around the Great Lakes, already experience water use that is a significant share of total availability (>40%). Given the likely changes in precipitation and temperature regimes under climate change, preparing such an analysis on a regular basis would seem desirable. Doing so will be easier once Statistics Canada begins regular publication of its *Water Stock Account* (see Section 2.3.2).

An overall assessment of water use could also be compared with predicted changes in water availability under different climate change scenarios to show how Canada's economic activities might be affected by climate change.

3.3.6 Agricultural Water Survey

Gaps

There are no significant gaps in the *Agricultural Water Survey* (see Section 3.3.6). The only concern in this regard is the fact that it runs only every second year, meaning that analysts are not provided with data that are as timely or frequent as they could be.

Analytical Opportunities

See *Industrial Water Survey* above.

In addition, the *Agricultural Water Survey* offers the chance to assess changes in the efficiency of irrigation over time by relating the quantity of water used for irrigation to the output of crops. The survey measures irrigation volumes for forage crops, field crops, fruit crops and vegetable crops. It also collects data on the type of irrigation systems used (sprinklers, micro-irrigation and surface irrigation) and on water conservation practices (for example, watering at night and water saving nozzles). Not all irrigations types are equally water efficient, so trends in system usage and conservation measures could provide interesting insight into farmers' decisions regarding water use. Finally, the survey provides data on the source of irrigation water (on-farm groundwater, on-farm surface water and off-farm water). Trends in groundwater use, in particular, would be worth analyzing to see if there is a general movement toward this source to compensate for reduced surface water quantities with warmer summertime temperatures.

3.3.7 Survey of Drinking Water Plants

Gaps

There are no significant gaps in the *Survey of Drinking Water Plants* (see Section 3.3.7). The only concern in this regard is the fact that it runs only every second year, meaning that analysts are not provided with data that are as timely or frequent as they could be.

Analytical Opportunities

See *Industrial Water Survey* above.

In addition, the raw (intake) water quality data collected through this survey have been paid relatively little attention to date. Monthly data are collected from each treatment plant on e-coli concentrations, turbidity and temperature of raw water. This makes the survey one of the largest and most consistent sources of water quality data available in Canada. Though the time series offered by the survey is short and the range of quality variables is limited, analysis of the data to see if any trends emerge would be worthwhile. It could point to areas where quality concerns may be arising.

3.3.8 Farm Environmental Management Survey

Gaps

There are no significant gaps the *Farm Environmental Management Survey* (see Section 3.3.8). The only concern in this regard is the fact that it runs only every fifth year, meaning that analysts are not provided with data that are as timely or frequent as they could be. Since this survey is conducted following the five-yearly Census of Agriculture, however, there is no real opportunity to increase its frequency. Smaller inter-censal

surveys could, however, be conducted to provide more frequent updates for the most important variables if the additional response burden could be justified.

Analytical Opportunities

The *Farm Environmental Management Survey* is a large survey (over 350 questions across two modules, one on crops and one on livestock) covering issues related to crop management, nutrient management, pesticide use, livestock housing, manure management, grazing management, wildlife damage, land and water management, waste management and environmental farm plans. As such, it offers a very wide range of analytical opportunities. The long time gaps between cycles of the survey limit the opportunities for longitudinal (period-to-period) analysis however; there have been only two iterations of the survey since its creation (2006 and 2011) and the next one is due to collect data for reference year 2017.

Statistics Canada produced a reasonably thorough cross-sectional analysis of the 2011 survey that exhausted some but not all of the analytical opportunities. The report covered the survey results related to environmental farm plans, pesticide use, surface water management and grazing management. This leaves variables related to crop management, nutrient management, livestock housing, wildlife damage and waste management unanalyzed. Of these, the data on livestock housing practices and nutrient management might offer the greatest analytical interest, since both of these deal with issues that are in the public eye (animal welfare and surface water quality).

Another analytical opportunity that could be exploited if results from the survey were linked with results from the *Census of Agriculture* is the relationship between farm economic and environmental performance. For example, the relation between farm income and the implementation of a farm environmental performance plan could be studied to see if farms with better environmental performance perform better or worse economically. Relationships between irrigation practices and economic performance could also be studied.

4 Research Agenda

In this section, we build upon the analysis of gaps and analytical opportunities in the preceding section to offer a research agenda. Some of what we suggest is work that would necessarily have to be carried out by Statistics Canada, as it concerns filling gaps in existing accounts or surveys. Other work could be done either by Statistics Canada or an external organization but if done externally would require approval for access to confidential statistics.[26] The remaining work could be done in either way.

To create the agenda, we have prioritized the gaps and analytical opportunities by considering:

- their likely cost in terms of human and financial resources
- the time likely required to complete them, and
- their likely impact on our understanding of the trends in the state of Canada's natural capital.

Our ranking, though necessarily subjective[27], reflects many years of experience working on and with environmental statistics.[28] We feel confident that the relative rankings do reflect the relative value of undertaking of each proposed research activity. We also believe all of the research activities are of value. It is only the timeframe within which we feel they should be undertaken and where the work should take place that distinguishes them in our proposed agenda

With respect to timeframe, we have grouped activities into four categories:

- **start now** – those for which the cost and time to implement are low and the impact is medium or high; these could likely be undertaken with existing resources
- **start as soon as possible** – those that have higher, but still reasonable costs/time requirements and medium to high impact; modest additional resources would likely be required to undertake these activities, but their significant likely impact suggest that finding those resources should be a priority
- **start in the next two years** – those that have high costs/time requirements but also high impact; substantial additional resources would be required to carry out these activities but, again, their likely significant impact makes the case for finding those resources strong
- **start in the longer term (three years and beyond)** – those that have high costs/time requirements and medium or low impact; the case for allocating resources to these activities, while still good, is not as compelling as for those higher in the agenda.

For each activity, we have indicated where we believe the work could be carried out – within Statistics Canada, in an external research organization or either.

Table 1 – Proposed Research Agenda

Timeframe for implementation	Research Activity	Where to carry out
Start now	Update the natural resource reserve index (see section 3.2.2)	Statistics Canada or external
Start now	Assess the distribution of natural resource wealth (see section 3.2.1)	Statistics Canada or external

[26] It is possible for outside organizations in some cases to carry out research that requires access to confidential Statistics Canada data. Programs exist to permit qualified researchers to access business statistics (including environmental statistic) and social statistics. While necessarily strict and restrained in their application, these programs nonetheless open up wide analytical possibilities to external researchers. The social statistics program has existed since the 1990s. The business statistics program is much more recent and its potential is only beginning to be realized.

[27] See Annex 2 for further details.

[28] The author worked on environmental statistics at Statistics Canada from 1990 to 2013, spending the final ten years of this period as Director of the responsible division.

Start now	Study decoupling using the *Material and Energy Accounts* (see section 3.2.2)	Statistics Canada or external (external researchers would require access to confidential input-output data)
Start now	Analyse the *Households and the Environment Survey* data at the municipal level (see section 3.3.2)	Statistics Canada or external
Start now	Build a regression model to understand the drivers of household environmental behaviour (see section 3.3.3)	Statistics Canada or external
Start now	Analyse the relationship between environmental protection expenditures and burdens on natural capital (see section 3.3.4)	Statistics Canada or external (external researchers would require access to confidential survey data)
Start now	Update the assessment of the demands for water in comparison to availability by basin (see section 3.3.5)	Statistics Canada or external
Start now	Assess trends in the source of irrigation water (see section 3.3.6)	Statistics Canada or external
Start now	Assess trends in the quality of drinking water plant intake water (see section 3.3.7)	Statistics Canada or external
Start now	Build a regression model to understand the links between farm characteristics and environmental management practices (see section 3.3.8)	Statistics Canada or external (external researchers would require access to confidential survey data)
Start now	Assess the efficiency of irrigation (see section 3.3.6)	Statistics Canada or external
Start as soon as possible	Report on *Natural Capital Trends in Canada* (see section 3.1.1)	Statistics Canada or external
Start as soon as possible	Report on *Green Growth in Canada* (see section 3.1.2)	Statistics Canada or external
Start as soon as possible	Update the *Physical Timber Stock Account* (see section 3.2.1)	Statistics Canada
Start as soon as possible	Compile a monetary water asset account (see section 3.2.1)	Statistics Canada
Start as soon as possible	Measuring multi-factor productivity including natural capital (see section 3.2.1)	Statistics Canada or external (could be more easily done within Statistics Canada)
Start as soon as possible	Add criteria air contaminant emissions to the *Physical Flow Accounts* (see section 3.2.2)	Statistics Canada
Start as soon as possible	Add non-hazardous solid waste flows to the *Physical Flow Accounts* (see section 3.2.2)	Statistics Canada
Start as soon as possible	Add sewage flows to the *Physical Flow Accounts* (see section 3.2.2)	Statistics Canada
Start as soon as possible	Add hazardous waste flows to the *Physical Flow Accounts* (see section 3.2.2)	Statistics Canada
Start as soon as possible	Add nutrient flows to the *Material and Energy Accounts* (see section 3.2.2)	Statistics Canada
Start as soon as possible	Expand the scope of the *Industrial Water Survey* to include the oil and gas extraction and hydroelectric power industries (see section 3.3.5)	Statistics Canada
Start within two years	Increase the frequency of publication of the *Land Account* (see section 3.2.1)	Statistics Canada

Start within two years	Compile a monetary land account including ecosystem service values (see section 3.2.1)	Statistics Canada
Start within two years	Increase the frequency of the *Waste Management Industry Survey* to annual (see section 3.3.1)	Statistics Canada
Start within two years	Increase the frequency of the *Households and the Environment Survey* to annual (see section 3.3.2)	Statistics Canada
Start within two years	Increase the frequency of the *Households and the Environment Survey: Energy Use Supplement* to annual (see section 3.3.3)	Statistics Canada
Start within two years	Increase the frequency of the *Survey of Environmental Protection Expenditures* to annual (see section 3.3.4)	Statistics Canada
Start within two years	Increase the frequency of the *Industrial Water Survey* to annual (see section 3.3.5)	Statistics Canada
Start within two years	Increase the frequency of the *Agricultural Water Survey* to annual (see section 3.3.6)	Statistics Canada
Start within two years	Increase the frequency of the *Survey of Drinking Water Plants* to annual (see section 3.3.7)	Statistics Canada
Start within two years	Reinstate the private vehicle motor fuel use survey (see section 3.3.3)	Statistics Canada
Start within two years	Develop supplements to the *Households and the Environment Survey* covering water use and various waste emissions (see section 3.3.3)	Statistics Canada
Start within two years	Expand the scope of the *Survey of Environmental Protection Expenditures* to include the agriculture, construction, transportation and service industries and for households and governments (see section 3.3.4)	Statistics Canada
Start within three years	Compile a marine resource asset account (see section 3.2.1)	Statistics Canada
Start within three years	Compile environmental activity accounts (see section 3.2.3)	Statistics Canada
Start within three years	Compile ecosystem accounts (see section 3.2.3)	Statistics Canada

The above research agenda, if carried out, would position Canada well to meet the challenge of measuring natural capital and understanding how it contributes to well-being and sustainability. Until the 1990s, Canada was a clear leader in the conceptual and empirical development of environmental accounts and statistics. Our standing has slipped somewhat since then. Tackling the agenda above would allow the country to regain that leadership status. No other developed country depends so much on its natural capital. That Canada should lead on this measurement agenda seems only fitting.

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Annex 1 – Details of natural capital measurement at Statistics Canada

Natural Resource Asset Accounts

Frequency: Annual

Scope: National and national/provincial/territorial depending on the resource

Description: The annual *Natural Resource Asset Accounts* measure quantities of key commercial natural resources *in situ* and the annual changes in these assets due to natural processes and human activity. The accounts are designed to be consistent with the international guidelines for natural resource asset accounting in the UN *System of Environmental-Economic Accounts*.

The *Natural Resource Asset Accounts*, which are recorded using both physical and monetary units, form the basis of the estimates of Canada's natural resource wealth that are included in the *National Balance Sheet Accounts*.[29]

The natural resources currently measured include:

- **Metallic and non-metallic minerals**: iron, uranium, copper, gold, lead, molybdenum, nickel, silver, zinc, sulphur and potash
- **Fossil fuels**: conventional crude oil, oil sands, conventional natural gas and natural gas liquids, bituminous, sub-bituminous and lignite coal
- **Timber**: Commercial timber stocks in accessible, non-reserved forest areas
- **Land**: Agricultural land and built-up land.

Availability: The length of the time series presented in the *Natural Resource Asset Accounts* varies with the resource in question. Many of the physical accounts begin in 1961, while the value estimates generally begin in the mid-1970s. These time series are available in various CANSIM tables and through the *Environment and Resource Accounts* module of Statistics Canada's web site.

Relation to natural capital: Sub-soil resources (fossil fuels and minerals) and land are two of the major categories of natural assets (the other being ecosystems). Data on the extent, quality and value of Canada's land and sub-soil resources and on the pressures imposed on them by human activities are therefore of high relevance to understanding natural capital. By offering both physical and monetary estimates of natural resource assets, the accounts provide two complementary perspectives on sustainability.

Highlights of recent findings

- Natural resources together (fossil fuels, minerals, timber and land) have represented close to 40% of Canada's national wealth since 2000, up considerably from 29% in 1990. The relative shares of the different resources have varied over time however.
- The share of sub-soil resources (fossil fuels and minerals) peaked at 19% of national wealth in 2008, when oil prices were at their historical high. By 2013, the most recent year for which data are available, sub-soil resources had fallen to just 8% of national wealth.
- The share of land (farmland and built-up land)[30] was fairly steady at about 20% of national wealth from 1990 to the early 2000s. By 2013, it had risen to 30%.
- Timber's share of national wealth has fallen steadily over time from a peak of 11% in 1995 to just 1% in 2013.
- In physical terms, a mixed story emerges. Reserves of many sub-soil resources, especially minerals, have declined since the 1960s/1970s when Statistics Canada's physcial time series begin. Fossil fuel

[29] In a first for a statistical agency, Statistics Canada began in late 2015 to publish estimates of natural resource wealth as part of the quarterly *National Balance Sheet Account.* More information is available here.
[30] Only farmland and so-called built-up land (land with structures on it) is valued in the *System of National Accounts*, where the figures for land values are taken from. No estimate is available for the value of other land areas such as protected areas or wilderness.

reserve trends have been more positive, especially for the oil sands. Timber has experienced a different trend depending on the perspective taken, area of forest or volume of wood.

- Stocks of many minerals have trended downward over time. In 2013, proven and probable reserves of **iron, lead, nickel, silver and zinc** were all substantially below their levels in the 1970s. Reserves of **copper and molybdenum** were also substantially below their 1970s levels, though they have been trending upwards again in recent years. **Gold and uranium** reserves have flucuated significantly since the 1970s but were at or near historic highs in 2013. **Sulphur** reserves are near historic highs after having declined between 1980 and 2003. Only **potash** reserves have steadily increased over the period.
- Established reserves of fossil fuels have varied considerably. **Conventional natural gas and natural gas liquids** reserves grew steadily until the early 1980s, then declined and have recent recovered somewhat to levels of the early 1970s. Trends in **coal** reserves are more difficult to assess because the data series became confidential in 2001. At that point, reserves were at the levels of the late 1980s but trending downward. **Convential oil reserves** declined substantially from their peak in the late 1960s until the late 1990s and have been relatively stable since. **Oil sands** reserves rose dramatically over the period from nearly nothing in the 1970s to be one of the largest in the world today.
- The trend in **timber stocks** moved in opposite directions depending on the way it was measured. In terms of the area of forest available for commercial timber harvesting, there was a slight increase between 1961 and 2003.[31] In volume terms, however, a different story emerges. The standing volume of timber in the commercial forest declined by 14% between 1961 and 2003, reflecting the conversion of high-volume old-growth forests to secondary forests over the period.

Physical Flow Accounts

Frequency: Annual

Scope: National

Description: The annual *Physical Flow Accounts* provide detailed measures of the flows of material and energy within the economy and between the economy and the environment. There are currently three sub-accounts:

- greenhouse gas emissions
- energy use
- water use.

The accounts offer considerable detail, with estimates for each of 111 different industries (including public administration) and for households. They are also comprehensive, accounting for all flows of greenhouse gases, energy and water between the economy and the environment. The industrial classification used is intentionally the same as of the economic *Input-output Accounts*, making it very easy to combine data from the two. Statistics Canada makes use of this compatibility to calculate several derived economy-environment variables, including the direct and indirect intensity of flows[32] and estimates of material and energy flows for categories of final demand.[33]

Availability: Unlike the *Natural Resource Asset Accounts*, the *Physical Flow Accounts* are produced only in physical units of measure. The accounts are designed to be consistent with the international guidelines for material and energy flow accounting in the UN *System of Environmental-Economic Accounting Central Framework*.

The time series presented in the *Physical Flow Accounts* began in 1990 for energy and greenhouse gases and in 2005 for water. Breaks in the time series in the late 2000s resulting from the revision of the *System of*

[31] Statistics Canada's *Physical Timber Stock Account* has not been updated since 2003 due to changes in the underlying data sources.
[32] Direct intensity is a measure of the materials or energy directly used or produced by an industry per unit of its economic output. Indirect intensity is a measure of the materials or energy embodied in the products purchased by an industry per unit of its economic output.
[33] Typically, material and energy flows are measured in terms of their production by an industry or household. Demand-based measures turn this on its head to look at flows from the perspective of the consumption activities that create the demand for that production.

National Accounts regrettably prevent comparison of data across the full time series. These time series are available in various CANSIM tables and through the *Environment and Resource Accounts* module of Statistics Canada's web site.

Relation to natural capital: Flows of energy, greenhouse gases and water are directly relevant to the quality and extent of natural capital. Energy use is related to depletion of energy and water assets, to land-use issues and to emissions of a variety of solid, liquid and gaseous wastes. Greenhouse gas emissions are related to the stability of the climate system. Water use is related to the quantity and quality of water assets.

Highlights of recent findings

- Total energy use by industries and households in Canada increased 2.1% in 2013, following a 0.2% gain the previous year. Greenhouse gas (GHG) emissions rose 1.9% in 2013 following a 1.0% increase in 2012. At the same time, economic output, as measured by Gross Domestic Product, rose 2.0% in 2012 and 2.1% in 2013. The faster rate of growth of economic output indicates a relative decoupling of growth from energy use; that is, the Canadian economy is becoming more energy efficient but not fast enough to result in lower overall energy use.
- Households continued to be the largest energy users in 2013, accounting for 23.7% of national energy use, up from 23.3% in 2012. Households were only responsible for 19.4% of national GHG emissions, however, since a large portion of household energy use is electricity, which does not directly contribute to household GHG emissions.
- The mining, quarrying and oil and gas extraction industries remained the largest source of GHG emissions in 2013, accounting for 21.5% of the national total.
- The electric power generation, transmission and distribution industry was by far the largest water consumer in 2011, accounting for 66% of all use. This industry saw its use decline by 10% from 2009 to 2011. Households, whose use declined by 3% from 2009 to 2011, were the next largest consumer at 10% of total use. Crop production and paper manufacturing each used 4% of all water in 2011. Oil and gas extraction accounted for just 1% of the total, though its use was up 19% from 2009.

Waste Management Industry Survey

Frequency: Biennial

Scope: National/provincial

Description: The biennial *Waste Management Industry Survey*[34] gathers information at the provincial level on the generation and management of municipal, non-hazardous solid waste in Canada. It reports on the quantities of residential and non-residential solid waste collected by municipalities and private waste management companies. The data reveal the share of waste collected that is sent for recycling versus that disposed of. In addition to data on waste quantities, the survey also reports on the financial and employment characteristics of companies, local governments and other public bodies involved in waste management.

Availability: Results from the survey up to the 2010 cycle are available in the publication Waste Management Industry Survey: Business and Government Sectors and in CANSIM tables 153-0041 to 153-0045. Following recent changes to Statistics Canada's dissemination practices, results for survey cycles after 2010 are available only in CANSIM.

Relation to natural capital: Flows of waste materials are relevant to the measurement of natural capital in several ways.

- First, landfills are an important and often controversial category of land use, especially around large cities where landfill space is scarce. Though the survey does not measure the area occupied by landfills, it does provide an indirect measure of the demand for landfill space in the form of waste disposal quantities.

[34] The Waste Management Industry Survey is actually two surveys, one directed at businesses providing waste management services and the other directed at municipalities offering these services.

- Second, waste disposal is the source of several pollutant flows to the environment. Landfills can release methane, a potent greenhouse gas, to the atmosphere and can leak contaminated water (known as leachate) into local surface and groundwater bodies.
- Third, rates of waste recycling provide an indication of the degree to which action is being taken to reduce reliance on primary materials such as aluminum and wood extracted from the environment.

Highlights of the 2012 survey

- Nationally, the amount of non-hazardous waste sent to private and public waste disposal facilities remained essentially stable from 2010 to 2012 after decreasing by 4% from 2008 to 2010.
- At 38%, residential waste accounted for slightly more than one-third of the total municipal solid waste disposed in 2012. The remainder was non-residential waste such as construction debris.
- As a share of total waste collected, waste diverted to recycling or organics processing facilities represented about 26% of the total in 2012. This was an increase of about 2% from 2008. Organics waste diversion continued to grow particularly rapidly, increasing by nearly 11% from 2010 and by some 87% since data collection began in 2002. Electronic waste recycling is the other rapidly growing category in recent years.

Households and the Environment Survey

Frequency: Biennial

Scope: National/provincial/Census Metropolitan Areas

Description: The *Households and the Environment Survey* measures a variety of household behaviours that are relevant to the environment. The survey has a large sample size (approximately 32,000 households), which permits estimates to be prepared at the national, provincial and census metropolitan area (large city) levels. The survey is carried out every second year as a supplement to Statistics Canada's *Labour Force Survey.*

The major themes covered by the *Households and the Environment Survey* are:

- energy use and home heating/cooling practices
- drinking water quality and consumption choices
- water conservation practices
- fertilizer and pesticide use
- recreational vehicles and gasoline-powered outdoor equipment
- indoor environmental quality
- composting
- management of household hazardous and electronic waste
- participation in nature-based activities
- environmentally conscious purchasing decisions.

Availability: Analysis of the national and provincial survey results up to the 2011 cycle are available in the publication *Households and the Environment* and in a variety of CANSIM tables. Following recent changes to Statistics Canada's dissemination practices, results for survey cycles after 2011 are available only in CANSIM.

Short analytical articles based on thematic data (for example, participation in environmental conservation activities) are also occasionally produced.

Finally, Statistics Canada produces a microdata file that is available upon request from the agency with detailed results for Canada, the provinces and census metropolitan areas, along with information on the socio-demographic, income and labour force characteristics of the population.

Relation to natural capital: Household activities are responsible for many of the flows of raw materials and pollutants between the environment and the economy. As such, data on key household environmental behaviours, such as participation in recycling programs and use of water-saving fixtures, are relevant to understanding – at least qualitatively – the trends in the burden that households place on natural capital.

Highlights from the 2013 survey

- In 2013, over half of Canadian households (55%) reported having an air conditioner, a slight increase from 2011.
- In 2013, half of Canadian households reported having a low-volume toilet, up from 47% in 2011. Households in dwellings with a water meter were more likely to have a low-volume toilet than households in dwellings that did not have a water meter (61% compared with 42%).
- In 2013, 32% of Canadian households that had a lawn or garden applied pesticides. This is a significant increase from 2011 (27%) and essentially the same share that did so in 1994 (31%), the earliest year for which data are available.[35]

Households and the Environment Survey: Energy Use Supplement

Frequency: Biennial

Scope: National/provincial

Description: The *Households and the Environment: Energy Use Supplement* is a supplement to the *Households and Environment Survey* focused on collecting more detailed information on the use of home heating equipment and fuels, household energy use, as well as participation in certain energy-saving activities. Like its parent survey, it is conducted every second year and is based on a large sample of households.

The major themes covered by the Energy Use Supplement are:

- heating equipment and fuel choices
- total household energy use
- household energy use by household and dwelling characteristics
- household lighting choices
- energy-saving and retrofitting practices.

Availability: The survey has been run only three times to date (2007, 2011 and 2013). Analysis of the results from those cycles are available in the publication *Households and the Environment: Energy Use*.

Relation to natural capital: Energy use is a major contributor to the demands placed on natural capital. Extraction, production and distribution of energy resources have significant impacts on air, soil and water quality, land use, climate stability and water use. End use of energy products further affects air water and soil quality and climate stability. Households are important users of energy products, so understanding their use and the factors that influence it is of interest in the context of reducing demands on natural capital.

Highlights from the 2013 survey:

- "Canadian households consumed 1.4 million terajoules of energy in their homes in 2013, up 7.2% from 2011"
- "Natural gas accounted for 50.6% of the total energy consumed by Canadian households, electricity for 44.6% and heating oil for 4.8%, a pattern similar to that of energy consumption in 2011."

Survey of Environmental Goods and Services

Frequency: Biennial

Scope: National/provincial

Description: The biennial *Survey of Environmental Goods and Services* produces national and provincial estimates of the production of "environmental" goods and services by industry. It replaced (beginning in 2008) the earlier *Environment Industry Survey*.

[35] The *Households and the Environment Survey* was first run as a pilot in 1991 and then again as a full survey in 1994. It was not run again until a new pilot was carried out in 2006. It has been run in its current form every second year since 2007. Pesticide use is one of the variables that have been consistently measured over time.

Environmental goods and services are those that are used, or can potentially be used, to measure, prevent, limit or correct environmental damage to water, air, soil as well as problems related to waste, noise and ecosystems. They also include clean or resource-efficient (eco-efficient) technologies that decrease material inputs, reduce energy consumption, recover valuable by-products, reduce emissions and/or minimize waste disposal problems.

The survey covers the following categories of environmental goods and services:

- renewable energy production
- management of non-hazardous waste
- management of industrial air pollution or flue gas
- industrial wastewater treatment and municipal sewage treatment
- remediation of ground water, surface water and leachate
- remediation of soil, sediment and sludge
- site remediation services and environmental emergency response services.

Availability: The new survey has been conducted three times (2008, 2010 and 2012) but changes in the survey content and methodology limit the degree to which the results from the three cycles are comparable. Analytical reports were produced for the earlier version of the survey but the results from the new survey have not been considered of high enough quality to support detailed analysis; they have been published only through short news releases.

Relation to natural capital: Developing new and improved technologies to limit the impact of economic activity on the environment is an important means by which the demands on natural capital can be limited. Better technologies can be used to reduce the flows of pollutants into the environment for a given unit of production. They can also reduce the need for raw materials by increasing the efficiency with which raw materials are transformed into finished products and by increasing the rate at which waste materials are recycled for subsequent inputs into production.

Highlights from the 2012 survey

- Canadian revenues from sales of environmentally related goods and services totalled almost $4.1 billion in 2012, up from $3.9 billion in 2010. Just under $1.8 billion was derived from sales of environmental goods, while sales of environmental services accounted for the remaining $2.3 billion.
- Sales of environmental services increased by 33% between 2010 and 2012. Revenues from environmental consulting services made up two-thirds of the sales total, accounting for $1.5 billion.
- Revenue from the sales of environmental goods fell by 19% from 2010. Most of this revenue was from the sales of renewable energy technologies, which accounted for about $600 million and was down from about $900 million in 2010.
- Businesses exported $748 million worth of environmental goods and services in 2012, with the majority (78%) going to the United States.

Survey of Environmental Protection Expenditures

Frequency: Biennial

Scope: National/provincial

Description: The biennial *Survey of Environmental Protection Expenditures* gathers information at the national and provincial levels on the costs imposed on industry to meet Canadian and international environmental regulations, conventions or voluntary agreements. The survey measures the expenditures made by Canadian industry to comply with present or anticipated environmental regulations, conventions and voluntary agreements. The survey also collects information on environmental management practices and environmental technologies used by industry for the purpose of preventing, abating or controlling pollution.

The major themes covered by the *Survey of Environmental Protection Expenditures* are:

- capital and operating expenditures on environmental monitoring
  capital and operating expenditures on environmental assessments and audits

- capital and operating expenditures on reclamation and decommissioning
- capital and operating expenditures on wildlife and habitat protection
- capital and operating expenditures on waste management and sewerage services
- capital and operating expenditures on pollution abatement and control processes (end-of-pipe)
- capital and operating expenditures on pollution prevention processes
- capital and operating expenditures on renewable energy and on greenhouse gas emission mitigation
- operating expenditures on environmental fees, fines and licenses.

Availability: Results up to the 2010 survey cycle are available in the publication Environmental Protection Expenditures in the Business Sector and in CANSIM tables 153-0052 to 153-0056. Following recent changes to Statistics Canada's dissemination practices, results for survey cycles after 2010 are available only in CANSIM.

Relation to natural capital: Industrial activities are an important driver of the demands on natural capital. Industries are major consumers of raw materials and major sources of pollution. They are also significant in shaping land-use patterns. Industrial expenditures made to protect the environment are, therefore, relevant in understanding trends in industrial demands on natural capital, even if the relation is indirect.

Highlights from the 2012 survey

- Canadian businesses reported that they spent $10.9 billion on environmental protection in 2012, up 15% from 2010.
- Two categories of expenditures—pollution abatement and control processes, and waste management and sewerage services—accounted for just over half the total.
- The oil and gas extraction industry reported the greatest spending: $4.7 billion, or 43%, of total business environmental protection expenditures. The mining and quarrying industry followed, spending $1.4 billion or 12% of total expenditures. Not surprisingly given the concentration of the oil and gas industry, businesses in Alberta reported the highest spending on environmental protection at just over $5.0 billion.
- Capital investments in renewable energy technologies totalled $547 million, up 20% from 2010. Investment was highest in biomass energy technologies, which accounted for more than half of the total in renewable energy technologies.

Industrial Water Survey

Frequency: Biennial

Scope: National/provincial/watershed basins

Description: The biennial *Industrial Water Survey* gathers information at the national and provincial levels on the volume of water brought into the facilities in the mining, thermal power and manufacturing industries, including information on the source, purpose, treatment and possible re-circulation of this water. Data are also collected on the volumes of wastewater treated and discharged and on the cost of intake and discharge. In addition to the national and provincial levels, the survey is also designed to produce results for major watershed basins, reflecting the fact that water flows do not respect political boundaries.

The major themes covered by the *Industrial Water Survey* are:

- water use by source, type and purpose (intake, recirculation, discharge, consumption)
- treatment of intake and discharge water
- costs of water acquisition, treatment and discharge.

Availability: Results up to the 2011 survey cycle are available in the publication *Industrial Water Use* and in a variety of CANSIM tables. Following recent changes to Statistics Canada's dissemination practices, results for survey cycles after 2011 are available only in CANSIM.

Relation to natural capital: Water is an important natural asset subject to both quantitative and qualitative degradation. Industries are major water users and their activities play a significant role in determining the quality and quantity of water available to other sectors of the economy and society as well as for ecological

functions. The trend in water use by industries is, therefore, important in understanding the demands the economy places on natural capital.

Highlights from the 2013 survey[36]

- According to data from the Industrial Water Survey, the three main industry groups covered by the survey had a total water intake of 30.2 billion cubic metres in 2013, up 8.1% from 2011. Of this total, power producers accounted for 84.9%, manufacturers for 13.1%, and mines for 2.0%.
- Among manufacturers, five industries accounted for almost 95% of the sector's water intake in 2013: paper, primary metals, chemicals, food and petroleum and coal.
- The vast majority of the intake was returned to the water supply. Prior to discharge, these same industries recirculated 8.3 billion cubic metres of water.
- The three groups had total costs of acquiring, treating and discharging water of almost $1.6 billion.

Agricultural Water Survey

Frequency: Biennial

Scope: National/provincial/watershed basins

Description: The biennial *Agricultural Water Survey* gathers information at the national and provincial levels on water use, irrigation methods and practices, and sources and quality of water used for agricultural purposes on Canadian farms. In addition to the national and provincial levels, the survey is also designed to produce results for major watershed basins, reflecting the fact that water flows do not respect political boundaries.

The major themes covered by the *Agricultural Water Survey* are:

- water use by source, type and purpose (intake, recirculation, discharge, consumption)
- treatment of intake and discharge water
- costs of water acquisition, treatment and discharge.

Availability: Results from the 2010 and 2012 survey cycles are available in the publication *Agricultural Water Use in Canada* and in various CANSIM tables.[37] Following recent changes to Statistics Canada's dissemination practices, results for survey cycles after 2012 are available only in CANSIM (e.g., the 2014 results.)

Relation to natural capital: Water is an important natural asset subject to both quantitative and qualitative degradation. Farms are major water users in some parts of the country and their activities play a significant role in determining the quality and quantity of water available to other sectors of the economy and society, as well as for ecological functions. The trend in water use by farms is, therefore, important in understanding the demands the economy places on natural capital.

Highlights from the 2014 survey

- Agricultural producers used approximately 1.7 billion cubic metres of water to irrigate their crops in 2014, the same amount reported in 2012.
- Irrigation declined in every province except Saskatchewan, Alberta and British Columbia. The very dry conditions in 2014 in British Columbia resulted in an increase of 18% in water use compared with 2012.
- Alberta accounted for three-quarters of all irrigation water applied to crops.
- Just less than 586,000 hectares of land were irrigated in 2014, of which 434,470 hectares were located in Alberta.

Survey of Drinking Water Plants

Frequency: Biennial

Scope: National/provincial/watershed basins

[36] These highlights from the 2013 survey were adapted from Statistics Canada's The Daily for October 27, 2015.
[37] This survey was not conducted prior to 2010.

Description: The biennial *Survey of Drinking Water Plants* gathers national and provincial level data related to the production of municipal drinking water. The survey is a census of drinking water plants serving more than 300 people. It gathers for information on volumes of water drawn and treated, treatment type, financial aspects of the operation, as well as source and treated water quality. In addition to the national and provincial levels, the survey is also designed to produce results for major watershed basins, reflecting the fact that water flows do not respect political boundaries.

The major themes covered by the *Survey of Drinking Water Plants* are:

- source water quality
- potable water production and use by sector
- population served
- water treatment methods
- capital and operating expenditures.

Availability: Results up to the 2011 survey cycle are available in the publication *Survey of Drinking Water Plants* and in a variety of CANSIM tables. Following recent changes to Statistics Canada's dissemination practices, results for survey cycles after 2011 are available only in CANSIM.

Relation to natural capital: Water is an important natural asset subject to both quantitative and qualitative degradation. Households and other consumers of municipal water are major water users and their activities play a significant role in determining the quality and quantity of water available to other sectors of the economy and society, as well as for ecological functions. The trend in water production by municipal drinking water plants is, therefore, important in understanding the demands the economy places on natural capital.

Highlights from the 2014 survey

- Drinking water plants produced 5,059 million cubic metres of potable water in 2013. Households representing 29.7 million people were served by these plants, in addition to industrial and commercial users.
- Total per capita water use, which accounts for residential, industrial, commercial and other uses of water provided by public utilities, averaged 466 litres per person per day in 2013, down 4% from 485 litres per person per day in 2011. When just residential use is considered, per capita use averaged 223 litres per person per day in 2013, down 11% from 251 litres per person per day in 2011.
- Surface water sources, such as lakes and rivers, supplied 88% of municipal drinking water.
- Just over $1 billion in capital expenditures were made to upgrade existing infrastructure and commission new components of water treatment plants in 2013. A further $977 million was spent on operation and maintenance.

Farm Environmental Management Survey

Frequency: Biennial

Scope: National/provincial

Description: The *Farm Environmental Management Survey*, which is conducted once every five years following the *Census of Agriculture*, gathers data at the national and provincial levels on farming practices on Canadian crop and livestock operations. The survey focuses on information related to manure storage and spreading, pesticide application, crop and nutrient management, grazing and the implementation of environmental farm plans.

The major themes covered by the *Farm Environmental Management Survey* are:

- environmental farm plans
- management practices
- wetlands and waterways
- grazing practices
- pesticide use.

Availability: Results from the 2011 survey cycle[38] are available in the report *Farm Environmental Management Survey*. No CANSIM tables are available for this survey.

Relation to natural capital: Farmland represents the most extensive human land use in Canada and is, therefore, an important determinant of the availability and quality of land assets for other sectors of the economy and society, as well as for ecological functions. Farming practices, such as fertilizer and pesticide application methods, are also important determinants of the quality of soil and water. Trends in farm management practices are relevant then to understanding – at least qualitatively – the trends in the burden that agriculture places on natural capital.

Highlights from the 2011 survey

- In 2011, 35% of Canadian farms had an environmental plan that listed risks such as soil erosion, water contamination or pesticide drift and detailed the management practices that should be put in place to mitigate those risks. Just over 7 out of 10 Quebec farms had a formal plan. In contrast, fewer than 3 out of 10 farms in Western Canada had a plan.
- In 2011, approximately 70% of Canadian crop farms reported applying herbicides to their crops. About 23% applied fungicides and another 15% applied insecticides.
- More than one quarter of farm operators reported having permanent wetlands on their operations.

Hazardous Waste Management Industry Survey

Frequency: Special study

Scope: National

Description: The one-time *Hazardous Waste Management Survey 2012* gathered data on the amount of hazardous waste handled by the hazardous waste management industry. It covered hazardous wastes accepted at transfer stations, intermediate processing facilities and final hazardous waste treatment and disposal/recycling facilities. The survey was funded by Environment Canada.

At the moment, Environment Canada is considering whether to fund further cycles of the survey.

Availability: The results of the survey, which were limited by data quality concerns, are available on request from Statistics Canada.

Relation to natural capital: Hazardous wastes represent a threat to the quality of air, water and soil and to human and animal life if not managed properly. Data on the quantities of these wastes handled by specialized waste management firms in Canada provide one indication of the scale of this threat.

Highlights from the 2012 survey

- 862 tonnes of mercury containing hazardous wastes were disposed of in 2012
- 109,339 tonnes of flammable/ignitable hazardous wastes were disposed of in 2012
- 48,374 tonnes of reactive and corrosive hazardous wastes were disposed of in 2012
- 263,459 tonnes of toxic and pathological wastes were disposed of in 2012
- 364,362 tonnes of other hazardous wastes were disposed of in 2012.

Water Asset Account

Frequency: Special study

Scope: National

Description: In 2010, Statistics Canada published a detailed report on water in Canada that included its first effort at measuring Canada's renewable water assets. To measure these assets, the study used a concept known as water yield that relates to the amount of water flowing in the nation's network of streams, rivers and lakes. A portion of this water originates from groundwater as it flows back to the surface and from melting

[38] A version of the survey was conducted in 2006 as well but no formal survey report was prepared.

glaciers. However, most of it is created when rain and melted snow flow over the ground, eventually reaching a surface water body.

Statistics Canada is currently working toward regular production of a water asset account based on the concepts and methods developed through this research.

Availability: The water asset measures are discussed in detail in Section 2 of the 2010 report on water in Canada. The methodology underlying them is outlined in two research reports: *The Water Yield for Canada As a Thirty-year Average (1971 to 2000): Concepts, Methodology and Initial Results* and *Using a Trend-Cycle Approach to Estimate Changes in Southern Canada's Freshwater Yield, from 1971 to 2004.*

Relation to natural capital: Fresh water is one of Canada's most important natural assets and the measures Statistics Canada is developing provide direct estimates of the physical scale and regional distribution of this asset.

Highlights from the 2010 research

- Canada's total renewable water assets, as measured by the average annual water yield, amount to 3,472 km^3. To put this in perspective, this is about as much water as there is in Lake Huron.
- Water assets are distributed unequally across the country. With an average annual water yield per unit area of 1.54 m3/m2, the Pacific Coastal drainage region has the highest water yield per unit area in the country. Drainage regions in the Prairies produce the least water, with average yields of 0.05 m3/m2, less than that for either Australia or South Africa.
- The southern part of the country, where 98% of the population is located, contains just 38% of the water assets.
- From 1971 to 2004, water assets in Southern Canada as a whole decreased by an average of 3.5 km^3 per year, which is equivalent to an overall loss of 8.5% of the water yield over this time period. Prairie water assets decreased by 0.56 km^3/yr. Over the 34-year period, this represents a total reduction of 20 km^3 of water yield, equivalent to roughly half of the long term, average annual water yield for the Prairies.

Trends in climate-related variables

Frequency: Special study

Scope: National/various sub-regions depending on the climate variable in question

Description: Between 2010 and 2012, Statistics Canada released five studies focused on trends in key climatic variables. The studies presented data related to Canada's climate and the impacts of climate change using short statistical analyses of climate-related data. The series was a result of collaboration between Statistics Canada, Environment Canada and Natural Resources Canada intended to make data related to Canada's climate easily and regularly accessible. The collaboration leveraged Statistics Canada effective and well-known data dissemination channels.

Availability: Though the intention at the time was that the analyses would be repeated periodically and that additional variables would be added over time, there have been no updates to the series since the final study was published in April 2012. The existing studies may be accessed here:

- glacier mass balance
- temperature
- precipitation
- sea ice
- snow cover.

Relation to natural capital: Climate change represents a significant threat to many of Canada's natural assets, particularly the nation's ecosystem assets. Changes in temperature and precipitation regimes along with increased variability in severe weather events put the stability of forests, wetlands, Alakes, rivers, estuaries and other terrestrial and aquatic ecosystems at risk. Climate change may represent an indirect threat

to the value of our fossil fuel assets (and the related manufactured and human assets) as well, if social and economic responses to it lead to the stranding of these assets in the ground. As such, trends in key climatic variables are relevant to understanding – at least qualitatively – the threats that climate change might represent for Canada's natural capital.

Highlights from the studies

- The six glaciers studied all experienced statistically significant reductions in their mass between 1965 and 2007.
- The national annual mean temperature departure from normal shows a warming trend of 1.4 degrees over the period 1948 to 2009.
- National annual precipitation increased by 17% over the period 1948 to 2009. The annual precipitation departure was 8% above the normal in 2009.
- All sea ice regions showed decreases in summer coverage from 1968 to 2010.
- Mean annual area of snow cover declined by 5.1% from 1972 to 2010.

Ecosystem accounts

Frequency: Special study

Scope: National/various sub-regions

Description: Statistics Canada published a groundbreaking report on ecosystem accounting in 2013. It represented the first effort at a comprehensive accounting for ecosystems published by a statistical agency anywhere in the world. The study was conducted with special funding from Policy Horizons Canada as a collaborative effort between several partner federal departments: Statistics Canada and Environment Canada as co-leads along with 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.

A major result of the study was a geodatabase that integrated various existing datasets to represent land cover and land use in Canada. Progress has been achieved in developing quality measures and advancing knowledge on monetary and non-monetary valuation. The study was carried out to be compatible with the UN *System of Environmental-Economic Accounting* objectives and guidelines for ecosystem accounting.

The study covered the following major themes:

- land cover change
- human modification of natural landscapes
- ecosystem services in the boreal forest
- biomass extraction from key ecosystems
- marine and coastal ecosystem goods and services
- freshwater and wetland ecosystem goods and services
- ecosystem goods and services in the Thousand Islands National Park.

Availability: The report can be accessed here. Though Statistics Canada has no current plans to undertake another comprehensive assessment of ecosystem assets, specific elements of the research are being pursued, specifically, the further development of accounts for freshwater ecosystems. Importantly, the interdepartmental working group created to carry out the project has remained in place and active since the study was published.

Relation to natural capital: Ecosystems are one of the major categories of natural assets (the other two being land [as space] and sub-soil resources). Data on the extent, quality and value of Canada's ecosystem and on the pressures imposed on them by human activities are therefore of high relevance to understanding natural capital.

Highlights from the study

- From 2001 to 2011, evergreen, deciduous and mixed wood forest areas across the country decreased from 3.1 million km^2 to 3.0 million km^2 (-4%), while scrubland 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. Only 7% of Canada's landmass is considered dependable for agricultural production.
- 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.
- From 2001 to 2011, the largest changes in land cover occurred as agricultural land reverted to natural landscapes.
- In 2010, an estimated 285.8 million tonnes of biomass (agricultural crops, livestock and poultry, milk, maple products and honey, forestry and marine products) were extracted for human use from Canada's terrestrial and aquatic ecosystems.
- 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%.
- Close to two million people lived within 100 km of the Thousand Islands Ecosystem in 2011, a 47% increase since 1981.
- The annual value of ecosystem goods and services flows assessed for the Thousand Island National Park is estimated to be between $12.5 million and $14.7 million (2012 dollars).

Natural Resource Reserve Index

Frequency: Special study

Scope: National

Description: In 2009, Statistics Canada published a study containing a methodology and initial results for a natural resource reserve index. This was the first time that such an index had been published by a statistical agency. Its goal was to overcome the difficulty of assessing the overall sustainability of Canada's key natural resources (fossil fuels, minerals and timber) posed by the fact that it is not possible to simply add up the physical extent of different resource reserves to determine whether they are being used sustainably over time. Nor is the sum of the monetary value of these reserves (that is, resource wealth) an indication of their physical sustainability, since prices are influenced by a number of factors beyond the size of the underlying assets. To address this problem, Statistics Canada proposed a volume index of natural resource reserves. Analogous to a price index but turned on its head, this index was constructed using the share of each resource in resource wealth in a base year to weight the physical measures of the reserves, allowing them to be added together into an index with a value of 100 in the base year.

Availability: The study can be accessed here. Statistics Canada has not updated this index since the study was published and has no immediate plans to do so. Interestingly, in the meantime, this indicator has been proposed by the OECD as one its headline green growth indicators to measure the sustainability of its member states' natural capital base. The OECD has plans to begin publishing natural resource index values for all member states in the next years.

Relation to natural capital: Key natural resources are important elements of natural capital. The sustainability of their use is, therefore, of interest from the point of view of both economic and ecological wellbeing. As a measure of the extent of these resources, the natural resource reserve index is directly relevant to understanding the evolution of natural capital. While the index is restricted in its current form to just fossil fuels, minerals and timber, there is no reason why it could not be extended to include other natural assets such as marine resources, land and even ecosystems. In principle, any natural asset that can be valued is amenable to inclusion in the index.

Highlights from the study

- Overall, the natural resource reserve index was found to be stable between 1997 and 2006, though its various components showed different trends. The index for fossil fuels was considerably up over the period, while that for minerals was considerably down. The timber index was stable.
- At the same time as the resource reserve index was stable, the total value of natural resource wealth increased substantially, growing by 10% per year. This suggests that factors other than the physical size of the underlying assets were responsible for the increase in resource wealth, raising concerns about the sustainability of that wealth.[39]

[39] Of course, we now know that much of that increase in wealth was not sustainable, particularly for the oil sands.

Annex 2 – Details of research activity rankings

The table below shows our subjective rankings of the various research activities that were proposed in Section 3. We ranked each activity according to the likely cost and time to implement and the potential impact of implementation on Canadians' understanding of the status of the country's natural capital. The rankings are based on our professional experience working with and on environmental statistics over the last 25 years.[40]

Note that the ratings used were as follows:

- 1 = low
- 2 = medium
- 3 = high

A simple algorithm was used to convert the ratings into a recommended timeframe for implementation for each activity. The lower the sum of the ratings, the sooner the activity was recommended for implementation.[41]

Table 2 - Details of research activity rankings

Cost to implement	Time to implement	Impact on data quality if implemented	Recommended timeframe for implementation	Proposed Research Activity
1	1	2	Start now	Update the natural resource reserve index (see section 3.2.2)
1	1	2	Start now	Assess the distribution of natural resource wealth (see section 3.2.1)
1	1	2	Start now	Study decoupling using the *Material and Energy Accounts* (see section 3.2.2)
1	1	2	Start now	Analyse the *Households and the Environment Survey* data at the municipal level (see section 3.3.2)
1	1	2	Start now	Build a regression model to understand the drivers of household environmental behaviour (see section 3.3.3)
1	1	2	Start now	Analyse the relationship between environmental protection expenditures and burdens on natural capital (see section 3.3.4)
1	1	2	Start now	Update the assessment of the demands for water in comparison to availability by basin (see section 3.3.5)
1	1	2	Start now	Assess trends in the source of irrigation water (see section 3.3.6)
1	1	2	Start now	Assess trends in the quality of drinking water plant intake water (see section 3.3.7)
1	1	2	Start now	Build a regression model to understand the links between farm characteristics and environmental management practices (see

[40] The author worked on environmental statistics at Statistics Canada from 1990 to 2013, spending the final ten years of this period as Director of the responsible division.

[41] The sums were calculated as the simple sum of cost and time ratings and the inverse of the impact rating (that is, an impact rating of 1 counted for 3 points in the sum; 2 counted for 2 points; 3 counted for 1 point). Activities with points totals of 4 or below were ranked "start now". Those with totals of 5 were "start as soon as possible". Those with totals of 6 were "start within two years". Those higher than 6 were "start within three years".

				section 3.3.8)
1	1	2	Start now	Assess the efficiency of irrigation (see section 3.3.6)
2	2	3	Start as soon as possible	Report on *Natural Capital Trends in Canada* (see section 3.1.1)
2	2	3	Start as soon as possible	Report on *Green Growth in Canada* (see section 3.1.2)
2	2	3	Start as soon as possible	Update the *Physical Timber Stock Account* (see section 3.2.1)
2	2	3	Start as soon as possible	Compile a monetary water asset account (see section 3.2.1)
2	2	3	Start as soon as possible	Measuring multi-factor productivity including natural capital (see section 3.2.1)
2	2	3	Start as soon as possible	Add criteria air contaminant emissions to the *Physical Flow Accounts* (see section 3.2.2)
2	2	3	Start as soon as possible	Add non-hazardous solid waste flows to the *Physical Flow Accounts* (see section 3.2.2)
2	2	3	Start as soon as possible	Add sewage flows to the *Physical Flow Accounts* (see section 3.2.2)
2	2	3	Start as soon as possible	Add hazardous waste flows to the *Physical Flow Accounts* (see section 3.2.2)
2	2	3	Start as soon as possible	Add nutrient flows to the *Material and Energy Accounts* (see section 3.2.2)
3	1	3	Start as soon as possible	Expand the scope of the *Industrial Water Survey* to include the oil and gas extraction and hydroelectric power industries (see section 3.3.5)
3	1	2	Start within two years	Increase the frequency of publication of the *Land Account* (see section 3.2.1)
2	2	2	Start within two years	Compile a monetary land account including ecosystem service values (see section 3.2.1)
3	1	2	Start within two years	Increase the frequency of the *Waste Management Industry Survey* to annual (see section 3.3.1)
3	1	2	Start within two years	Increase the frequency of the *Households and the Environment Survey* to annual (see section 3.3.2)
3	1	2	Start within two years	Increase the frequency of the *Households and the Environment Survey: Energy Use Supplement* to annual (see section 3.3.3)
3	1	2	Start within two years	Increase the frequency of the *Survey of Environmental Protection Expenditures* to annual (see section 3.3.4)
3	1	2	Start within two years	Increase the frequency of the *Industrial Water Survey* to annual (see section 3.3.5)
3	1	2	Start within two years	Increase the frequency of the *Agricultural Water Survey* to annual (see section 3.3.6)
3	1	2	Start within two years	Increase the frequency of the *Survey of Drinking Water Plants* to annual (see section 3.3.7)

3	1	2	Start within two years	Reinstate the private vehicle motor fuel use survey (see section 3.3.3)
3	2	3	Start within two years	Develop supplements to the *Households and the Environment Survey* covering water use and various waste emissions (see section 3.3.3)
3	1	2	Start within two years	Expand the scope of the *Survey of Environmental Protection Expenditures* to include the agriculture, construction, transportation and service industries and for households and governments (see section 3.3.4)
3	3	3	Start within three years	Compile a marine resource asset account (see section 3.2.1)
3	3	2	Start within three years	Compile environmental activity accounts (see section 3.2.3)
3	3	3	Start within three years	Compile ecosystem accounts (see section 3.2.3)