Catalogue no. 16-201-X

Human Activity and the Environment

Agriculture in Canada

2014

Statistics Canada Statistique Canada

Canada

How to obtain more information

For information about this product or the wide range of services and data available from Statistics Canada, visit our website, *www.statcan.gc.ca*.

You can also contact us by

e-mail at *infostats@statcan.gc.ca*

telephone, from Monday to Friday, 8:30 a.m. to 4:30 p.m., at the following toll-free numbers:

- Statistical Information Service 1-800-263-1136
- National telecommunications device for the hearing impaired 1-800-363-7629
- Fax line 1-877-287-4369

Depository Services Program

- Inquiries line 1-800-635-7943
- Fax line 1-800-565-7757

To access this product

This product, Catalogue no. 16-201-X, is available free in electronic format. To obtain a single issue, visit our website, *www.statcan.gc.ca* and browse by “Key resource” > “Publications.”

Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner. To this end, this agency has developed standards of service that its employees observe. To obtain a copy of these service standards, please contact Statistics Canada toll-free at 1-800-263-1136. The service standards are also published at *www.statcan.gc.ca* under “About us” > “The agency” > “Providing services to Canadians.”

Statistics Canada
Environment, Energy and Transportation Statistics Division

Human Activity and the Environment

Agriculture in Canada

2014

Published by authority of the Minister responsible for Statistics Canada

November 2014

Catalogue no. 16-201-X

ISSN 1923-6751

Frequency: Annual

Ottawa

Cette publication est également disponible en français.

Note of appreciation

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

User information

Symbols

The following standard symbols are used in Statistics Canada publications:

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

Acknowledgements

Human Activity and the Environment 2014 was prepared by the Environment, Energy and Transportation Statistics Division under the direction of Kevin Roberts (Director), Carolyn Cahill (Assistant Director) and François Soulard (Project Manager). Jane Lin and Jennie Wang were the editors and Michelle Tait managed production and dissemination.

The feature article was written by:

Gabriel Gagnon

Cindy Lecavalier

François Soulard

Joe St. Lawrence

Michelle Tait

Jennie Wang

Thanks to the following people and areas for their support in data provision, subject matter expertise, map creation, translation, reviewing, data verification, proofreading and dissemination:

Pat Adams
Census of Agriculture
Arezu Alami
Avani Babooram
Martin Beaulieu (Agriculture Division)
Cindy De Cuypere
Gordon Dewis
Dissemination Division
Giuseppe Filoso
Jeff Fritzsche
Maxime Gaudet
Mark Henry
Jill Jensen (Agriculture and Agri-Food Canada)
Laura Kemp
Hugo Larocque
Haileigh McDonald
John Marshall
Tim Martin (Agriculture and Agri-Food Canada)
Hugues Morand (Agriculture and Agri-Food Canada)
Soheil Rastan
Jeffrey Smith (Agriculture Division)
Translation and Terminology Services
Patrick Verreault (Agriculture and Agri-Food Canada)

The support and co-operation of Agriculture and Agri-Food Canada is also gratefully acknowledged.

Table of contents

Table of contents – continued

Table of contents – continued

Highlights

Ecological infrastructure for agriculture

- Over the 40 years from 1971 to 2011, farm area in Canada has declined (-6%) from 68.7 million hectares to 64.8 million hectares. The loss of 3.9 million hectares of farm area is equal to an area approximately the size of Vancouver Island in British Columbia.
- Canada has more than 50.5 million hectares of dependable agricultural land.[1] Most of this dependable agricultural land is found in the Prairies and Boreal Plains ecozones.[2] Farm area[3] located on dependable agricultural land has declined by 969,802 hectares more recently from 2001 to 2011.
- Settled area[4] on dependable agricultural land in Canada increased by 19% over a similar period (2000 to 2011). By ecozone, the largest increase occurred in the Mixed Wood Plains (which is bounded by three Great Lakes in the south and extends along the St. Lawrence River to Quebec City), where the settled area on dependable agricultural land grew by 128,030 hectares (+27%)—over half this growth came from the Greater Golden Horseshoe.[5]
- In the Prairies ecozone, an area that stretches from the Rocky Mountains in Alberta to the Red River valley in Manitoba, farm area made up 86% of the total area. Further, cropland[6] accounted for more than half of total farm area in the Prairies ecozone.

Ecosystem goods and services from agriculture

- Agricultural ecosystems supported the production of more than 134 million tonnes of farm output in 2012, valued at $54.2 billion. The Prairie provinces were responsible for 63% of food and fodder crop production in 2012; Quebec, Ontario and Alberta accounted for 74% of livestock and poultry meat production; and Quebec and Ontario accounted for 70% of milk production and 55% of egg production.
- Natural and semi-natural areas on farms can supply many ecosystem services including habitat provision, water regulation and scenery. In 2011, woodlands and wetlands accounted for 8% of farm area, while natural pasture accounted for a further 23%.
- According to the 2011 Census of Agriculture, 3,272 farms in Canada reported owning honeybees not only for honey production but also to improve pollination.

1. Land in classes 1 to 3 in the Canada Land Inventory has been termed ‘dependable agricultural land’ and represents land with a high capability for sustained agricultural production.
2. For geographic coverage, please see Map *1*, Appendix H in Statistics Canada, 2013, “Measuring ecosystem goods and services in Canada,” *Human Activity and the Environment*, Catalogue no. 16-201-X.
3. Farm area represents the category ‘Total farm area’ from the Census of Agriculture—this includes the following land use categories: cropland, summerfallow, tame or seeded pasture, natural pasture and other land.
4. Settled area is based on Agriculture and Agri-Food Canada’s (AAFC) 30 m land cover code for developed areas. Some northern areas only partially covered by the AAFC land cover (see Map *1*, Appendix C in Statistics Canada, 2013, “Measuring ecosystem goods and services in Canada,” *Human Activity and the Environment*, Catalogue no. 16-201-X for geographic coverage) were supplemented with estimates derived from Statistics Canada’s settlements data and AAFC’s 30 m land cover.
5. The Greater Golden Horseshoe is a 33,200 km^2 area located to the west of Lake Ontario including the Greater Toronto Area. Please see Map *3.2* in Statistics Canada, 2013, “Measuring ecosystem goods and services in Canada,” *Human Activity and the Environment*, Catalogue no. 16-201-X.
6. Cropland is land producing field crops, hay, fruit, vegetables, sod and nursery crops.

Beneficiaries of agricultural ecosystem goods and services

- In 2011, the Canadian farm population was 650,395 or 2% of Canadians; however, the farm population represented 10% of the population in rural areas. From 1991 to 2011, the number of farm operators decreased from 390,875 to 293,925 or 25%.
- Primary agriculture—crop and animal production—accounted for 1.1% of Canada's gross domestic product and 1.6% of employment in 2010.
- Over 70% of the food Canadians bought in 2010 was produced domestically. Canada is particularly self-sufficient for meat, dairy (including eggs), breads and cereals.

Environmental management

- The widespread adoption of no-till practices and the steady decline in the area of summerfallow land have resulted in cropland turning from a net source of greenhouse gas emissions into a net sink.[7] No-till involves direct seeding into crop residue, avoiding any mechanical tillage of the soil. No-till practices increased from 7% in 1991 to 56% in 2011.
- In 2011, soil nutrient testing was performed annually on 20% of crop farms while testing was done every two to three years on 36% of crop farms. Thirteen percent reported no soil nutrient testing.
- In 2011, 55% of crop farms used crop rotation as an alternative method of pest control, with more than half of the crop farms in Ontario, Saskatchewan, Manitoba and Alberta using this method to disrupt pest cycles.
- In 2011, 56% of livestock farms had pastures or grazing paddocks adjacent to surface water. This proportion was highest in Saskatchewan (74%) and lowest in Quebec (33%). In 2011, 15% of livestock farms allowed grazing livestock no access to surface water, 18% allowed limited access, and 35% allowed unlimited access during the grazing season.
- In 2011, 24% of farms had permanent perennial forages on erodible land, 20% used slow release fertilizer products and 18% added straw to improve soil condition. Cover or companion crops were seeded on 15% of farms and 9% planted winter cover or green manure crops after harvest.

7. A net carbon sink absorbs or takes up more carbon than it releases as part of the carbon cycle.

Related products

Selected publications from Statistics Canada

11-526-X	Households and the Environment
16-001-M	Environment Accounts and Statistics Analytical and Technical Paper Series
16-002-X	EnviroStats
16-257-X	Environment Accounts and Statistics Product Catalogue
16-401-X	Industrial Water Use
16-402-X	Agricultural Water Use in Canada
16-403-X	Survey of Drinking Water Plants
16-507-X	Human Activity and the Environment - Teacher's Kit, 2013
16F0006X	Environmental Protection Expenditures in the Business Sector
21-023-X	Farm Environmental Management - Survey Report

Selected technical and analytical products from Statistics Canada

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

Selected CANSIM tables from Statistics Canada

153-0011	Value of timber stocks (methods I and II), annual
153-0032	Energy use, by sector, annual

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

Selected surveys from Statistics Canada

1209	Survey of Environmental Goods and Services
1736	Waste Management Industry Survey: Government Sector
1903	Survey of Environmental Protection Expenditures
2009	Waste Management Industry Survey: Business Sector
3450	Farm Financial Survey
3881	Households and the Environment Survey
5044	Farm Environmental Management Survey

5114	Canadian System of Environmental and Resource Accounts - Natural Resource Stock Accounts
5115	Canadian System of Environmental and Resource Accounts - Material and Energy Flow Accounts
5120	Industrial Water Survey
5145	Agricultural Water Survey

Selected summary tables from Statistics Canada

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

Section 1

Introduction

Land, soil, water and climate are important elements of ecological infrastructure that provide the foundation for agricultural activity in Canada. In some areas of the country, agriculture occupies a large proportion of the landscape and particularly in the Prairies and parts of southern Ontario it can be the dominant land use. Not all land is suitable for agriculture, however. In addition, much of Canada's farmland is located in areas where there are many other competing uses for the land.

Although Canada's cities, towns and roads—its built-up areas—cover only 0.1% of the country's landscape, development pressures can result in the loss of prime agricultural land and the loss of many valuable ecosystem services and benefits that agricultural ecosystems[1] provide to society, from habitat for wildlife, to water flow regulation and space for recreational activities and aesthetic enjoyment.

Agriculture contributes to the lives of Canadians across the country, providing food, work and helping maintain the connection between people and land. Canadian agriculture also benefits people around the world.

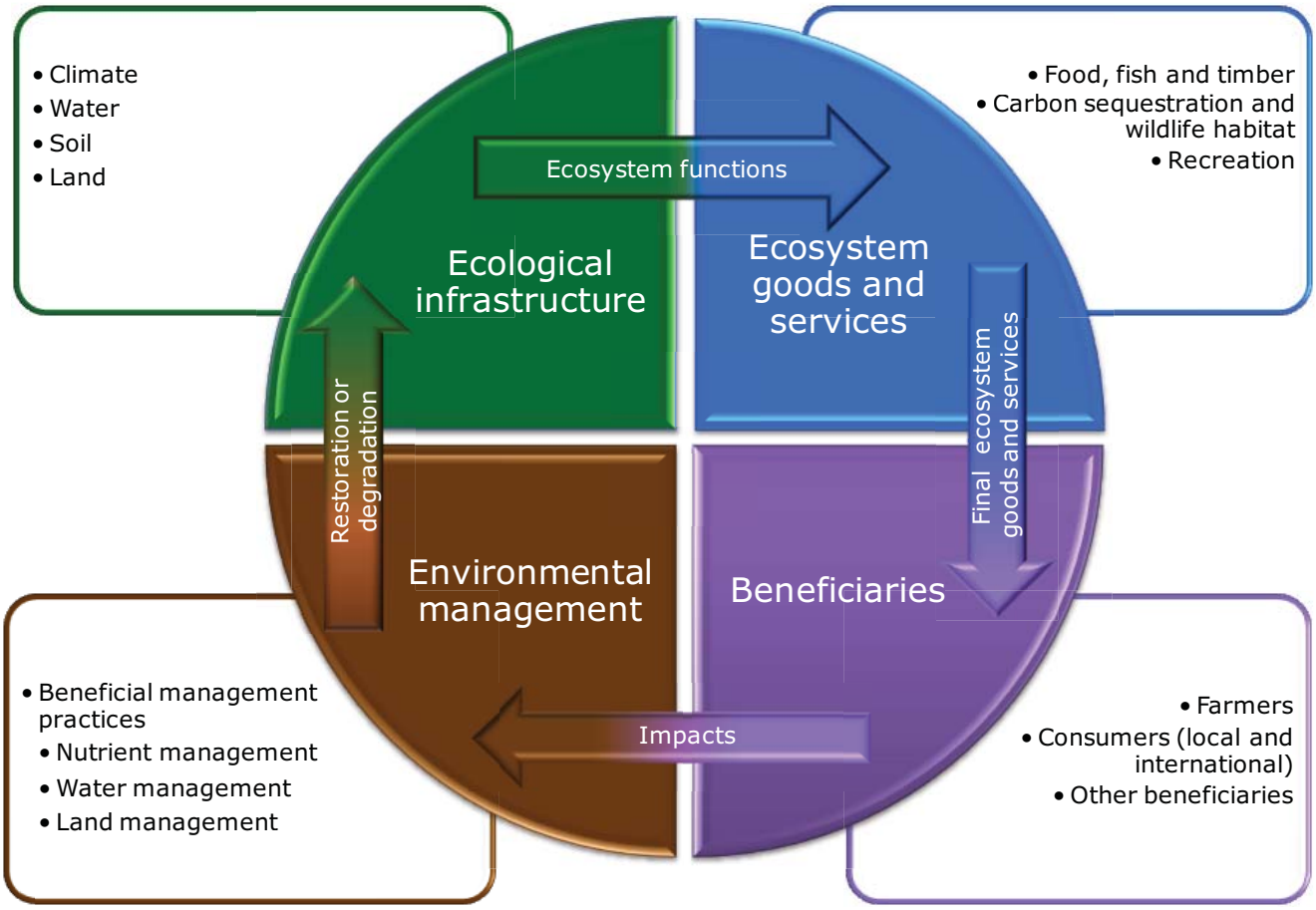
At the same time, it is important to recognize the potential environmental impacts resulting from agricultural activities—the agricultural industry is the largest water consumer in the country,[2] nutrients from fertilizer and manure can impact water quality[3] and some farm activities can result in emissions of air pollutants and greenhouse gases.[4,5] Many farmers have adopted specific management practices to prevent or minimize these impacts and restore or improve ecosystem services.

The Ecosystem Goods and Services conceptual framework (Figure 1.1) illustrates the structure of this study. It covers: the ecological infrastructure supporting agricultural activity (Section 2), ecosystem goods and services from agriculture (Section 3), the main beneficiaries of these goods and services (Section 4) and the environmental impacts and management activities associated with agriculture (Section 5). Section 6 provides an example to illustrate how agricultural information from the four quadrants can be integrated into a system of environmental accounts that follow international guidelines being developed by the Food and Agriculture Organization of the United Nations (FAO). Section 7 concludes with a short listing of areas requiring further research. A glossary of terms used in the publication is available in Appendix B.

1. Agricultural ecosystems are ecosystems under agriculture management. They include the full array of living and non-living ecosystem components and include both cultivated lands and the surrounding or intermixed uncultivated areas, as well as associated plants, animals and other organisms.
2. Environment Canada, 2013, *Water Withdrawal and Consumption by Sector*, *http://ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=5736C951-1* (accessed February 3, 2014).
3. Environment Canada, 2013, *Reducing agricultural impacts on the environment*, *www.ec.gc.ca/dd-sd/default.asp?lang=En&n=213DE9BF-1* (accessed May 9, 2014).
4. Environment Canada, 2013, *National Emission Trends for Key Air Pollutants, 1985-2011*, *www.ec.gc.ca/inrp-npri/default.asp?lang=en&n=0EC58C98-#sommaires* (accessed February 3, 2014).
5. Environment Canada, 2014, *National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada*, *www.ec.gc.ca/ges-ghg/* (accessed May 22, 2014).

Figure 1.1

Ecosystem Goods and Services conceptual framework for agriculture



Note(s): This diagram illustrates the ecosystem goods and services (EGS) conceptual framework for agriculture. Ecological infrastructure, including climate, water, soil and land generate ecosystem functions which result in the production of a large array of EGS, and which can be categorized as provisioning services (e.g., food, fish and timber), regulating services (e.g., carbon sequestration and wildlife habitat) and cultural services (e.g., recreation). Agricultural goods are the result of joint production using both agricultural ecosystems and human inputs. EGS related to agriculture can include both 'supporting' or 'intermediary' services that are needed to produce other 'final' agricultural EGS that benefit people directly. Beneficiaries of agricultural EGS can be local, regional or global and may include farmers, consumers and others. Activities associated with the production of agricultural output by farmers, as well as the use of final EGS by consumers and others can result in impacts to ecosystem integrity. Farm management activities and practices, including beneficial management practices for nutrients, water and land can result in the conservation, restoration or degradation of ecological infrastructure.
Source(s): Statistics Canada, Environment, Energy and Transportation Statistics Division, 2014.

The annual *Human Activity and the Environment* publications bring together data from many sources to present a statistical portrait of Canada's environment, with special emphasis on human activity and its relationship to natural systems—air, water, soil, plants and animals. Each issue provides accessible and relevant information on an environmental issue of concern to Canadians.

The 2014 article "Agriculture in Canada" gathers together a variety of statistics describing agriculture

Note to readers

Many of the statistics in this report are presented using geographical classifications that focus on ecological and hydrographical characteristics of the earth's surface, rather than administrative boundaries such as provinces and municipalities.

The Ecological Framework of Canada divides the country into 15 terrestrial ecozones that share common ecological characteristics, such as climate, physiography, vegetation, soil, water, fauna and land use (Map *1*, Appendix H, in Statistics Canada, 2013, "Measuring ecosystem goods and services in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X). Ecozones can be further broken down into 53 ecoprovinces, 194 ecoregions and 1,021 ecodistricts, each characterized by greater levels of detail on regional ecological characteristics. According to data from the Census of Agriculture, farms are located in 8 of Canada's 15 ecozones.

Statistics Canada's drainage region classification divides the country according to water flows into five ocean drainage areas: the Pacific Ocean, the Arctic Ocean, the Atlantic Ocean, Hudson Bay, and the Gulf of Mexico. These areas can be further subdivided into 25 drainage regions (Map *1.2* in Statistics Canada, 2010, "Freshwater supply and demand in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X), which cover all the land and interior freshwater lakes and rivers across the country. Drainage regions are based on an aggregation of 974 sub-sub-drainage areas.[6] Farms can be found in 22 of the 25 drainage regions across the country.

from the perspective of ecosystem goods and services (see Textbox 1).

6. Statistics Canada, 2009, *Standard Drainage Area Classification (SDAC) 2003*, *www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdac-ctad-eng.htm* (accessed April 10, 2014).

Textbox 1: What are ecosystem goods and services?

Ecosystems are communities of interacting organisms—living species such as plants, animals and microorganisms—and their physical environment that function together as a unit. Ecosystems produce a wide variety of goods and services from which people benefit, which are collectively known as ecosystem goods and services (EGS). For an in-depth report on ecosystem accounting and valuation, please see Statistics Canada, 2013, "Measuring ecosystem goods and services in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X.

For example, plants and trees in forest ecosystems produce clean air, while wetlands filter and control the flow of water, providing clean water and providing flood protection. Agricultural ecosystems contribute to the production of food, through the provision of fertile soil, pollination and pest regulation services with additional inputs of fertilizers, pesticides, energy and labour by farmers. These different ecosystems can also provide recreational and aesthetic benefits, among others.

EGS can be classified into provisioning, regulating and cultural services.

- Provisioning services produce the goods upon which people rely, including crops, livestock, fish or timber.
- Regulating services such as climate, water flow, and air quality regulation result from the capacity of ecosystems to control climatic, hydrological and bio-chemical cycles, as well as biological processes.
- Cultural services provide people with psychological, intellectual and symbolic benefits through recreation, knowledge development, relaxation, and spiritual reflection.

An additional category termed 'supporting services' is sometimes recognized to address the fact that many underlying ecosystem functions and processes are required to produce all other ecosystem services. These services are considered to be intermediate outputs that flow within and between ecosystems, and which contribute to the production of final ecosystem outputs that benefit people.

Different types of ecosystems provide different types of EGS—cropland, for example might produce quite a different array and amount of EGS than forests or wetlands. An ecosystem's capacity to produce EGS can be affected, both positively and negatively, by human activity.[7]

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

What you should know about this study

This report makes extensive use of data from the following five sources:

Census of Agriculture: The Census of Agriculture collects a wide range of data on the agriculture industry such as number of farms and farm operators, farm area, business operating arrangements, land management practices, livestock and crop inventories, operating expenses and receipts, farm capital and farm machinery and equipment. These data provide a comprehensive picture of the agriculture industry across Canada every five years at the national, provincial and sub-provincial levels. For more information see Statistics Canada, 2012, *About the Census of Agriculture*, *www.statcan.gc.ca/ca-ra2011/110002-eng.htm*.

Farm Environmental Management Survey: The 2011 Farm Environmental Management Survey was conducted to gather information about farming practices on Canadian crop and livestock operations. The survey focused on information related to manure spreading, pesticide application, grazing and the implementation of environmental farm plans over the 2011 calendar year. For more information, see Statistics Canada, 2012, *Farm Environmental Management Survey (FEMS)*, *http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5044*.

Households and the Environment Survey: The Households and the Environment Survey measures the environmental practices and behaviours of Canadian households that relate to the condition of our air, water and soils. The survey was also designed to collect data to develop and improve three key environmental indicators: air quality, water quality and greenhouse gas emissions. For more information see Statistics Canada, 2014, *Households and the Environment Survey (HES)*, *http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3881*.

Interpolated Census of Agriculture: Since Statistics Canada's Standard Geographical Classification units (such as census metropolitan areas) generally do not correspond with biophysical units (such as ecological regions or drainage areas), Agriculture and Agri-Food Canada (AAFC), in collaboration with Statistic Canada's Agriculture Division, have developed a process for assigning Census of Agriculture data to environmental geographies such as drainage areas. For more information see Government of Canada, 2013, *Interpolated Census of Agriculture*, *http://data.gc.ca/data/en/dataset/1dee8513-5c73-43b6-9446-25f7b985cd00*.

Agricultural Water Survey: This survey is conducted to gather information on irrigation water use, irrigation methods and practices, and sources and quality of water used for agricultural purposes on Canadian farms. The results help farm operators, governments and the Canadian public gain a better understanding of the demand for water and how it is used on Canadian farms. For more information see Statistics Canada, 2012, *Agricultural Water Survey (AWS)*, *http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5145*.

Section 2

Elements of ecological infrastructure

Elements of ecological infrastructure, such as soil, water, climate, and living organisms are required for successful agriculture. The interactions of these structures within and across ecosystems result in ecosystem processes and functions, such as photosynthesis and nutrient cycling that are vital for crop production. This section examines elements of the ecological infrastructure required for productive agriculture to take place, with a focus on

Textbox 2: Climate, water and soil

Climate, water and soil are important factors affecting where different types of agriculture can be successful. Crops require sunlight, warm temperatures, and an adequate supply of water from precipitation or irrigation during the growing season.

Changes in average temperature, growing season length and the amount, intensity and timing of precipitation due to climate change are occurring[1] and are expected to affect agricultural practices. In the future, suitable conditions may allow agricultural activities to expand northward[2] and crop varieties may change; however, crops may also suffer from heat stress, drought, and changes in pest populations, while increased rainfall intensity and flood events could have the potential to cause soil erosion and loss of soil nutrients.[3]

In Canada, light and temperature can be limiting factors affecting crop growth. Growing degree days—a measure of the availability of heat for plant growth—are used in agriculture to track temperature accumulation. Growing degree days are calculated on a daily basis as the difference between the daily mean temperature and a reference temperature of 5 degrees Celsius. The number of degree days varies across the country from less than 250 in locations in the North to more than 2,000 in southern locations found in Ontario, Quebec and British Columbia.[4] Longer growing seasons combined with warmer temperatures during the growing season have resulted in increases in growing degree days, mainly in the southern part of the country.[5] While Canada has abundant renewable freshwater supplies—3,472 km^3 of average annual water yield—water renewal in some areas of the country is more limited; 0.5 km^3 in the Missouri drainage region and 4.2 km^3 in the Okanagan–Similkameen drainage region.[6] Runoff ranges from less than 50 mm in the southern Prairies to over 1,540 mm in the Pacific Coastal drainage region. The timing of water availability also matters, since peak demand for water often coincides with periods when the water yield is low. Canada's water yield has decreased on average 8.5% from 1971 to 2004.[7]

Soil quality comprises many characteristics, some of which vary with agricultural practices (e.g., pH, organic content, nutrients) and others which are largely unalterable (e.g., topography, internal drainage, soil texture).[8] Nitrogen, phosphorus and potassium, as well as a variety of other macro and micronutrients are needed for plant growth, but are not always available from the soil, requiring fertilization.

Worldwide, use of nitrogen fertilizer increased 30%, while use of phosphate fertilizer increased 19% from 2002 to 2011.[9] Nitrogen is abundantly available in the atmosphere and can be recovered to produce synthetic fertilizer through the Haber-Bosch process.[10] Other sources of nitrogen include nitrogen fixation from symbiotic interactions[11] between bacteria and legumes and the use of animal manures. Nearly all phosphorus fertilizer, however, is produced from phosphate rock, a non-renewable resource that is becoming increasingly scarce.[12]

the availability of suitable farmland. See Textbox 2 for more information on climate, water and soil.

1. Zhang, X., R. Brown, L. Vincent, W. Skinner, Y. Feng and E. Mekis, 2011, "Canadian climate trends, 1950-2007," *Canadian Biodiversity: Ecosystem Status and Trends 2010*, Technical Thematic Report No. 5, Canadian Councils of Resource Ministers, *www.biodivcanada.ca/default.asp?lang=En&n=137E1147-0* (accessed April 15, 2014).
2. Hewitt, J., T. Brierley, K. Chen, and H. Hill, 2008, *Assessment of Climate Change Impacts on Agricultural Land-Use Suitability: Spring Seeded Small Grains on the Prairie*, Agriculture and Agri-Food Canada and Environment Canada, *http://www4.agr.gc.ca/resources/prod/doc/pfra/pdf/assess_clim_chang_prairies_e.pdf* (accessed April 15, 2014).
3. OURANOS, n.d. (no date), *Vers l'adaptation aux changements climatiques*, *http://adaptation.ouranos.ca/en/* (accessed April 16, 2014).
4. Natural Resources Canada, 1981, "Canada – Growing Degree-Days," *The National Atlas of Canada, 5thEdition*, *http://geogratis.gc.ca/api/en/nrcan-rncan/ess-sst/610cd0b8-4791-5374-8245-a12a053bcd4a.html* (accessed April 16, 2014).
5. Zhang, X., R. Brown, L. Vincent, W. Skinner, Y. Feng and E. Mekis, 2011, "Canadian climate trends, 1950-2007," *Canadian Biodiversity: Ecosystem Status and Trends 2010*, Technical Thematic Report No. 5, Canadian Councils of Resource Ministers, *www.biodivcanada.ca/default.asp?lang=En&n=137E1147-0* (accessed April 15, 2014).
6. Statistics Canada, 2010, "Freshwater supply and demand in Canada," *Human Activity and the Environment,* Catalogue no. 16-201-X.
7. Statistics Canada, 2010.
8. DSS Management Consultants Inc, 2010, *Valuation of Ecological Goods & Services in Canada's Natural Resources Sectors*, Technical report submitted to Ecosystems and Biodiversity Priorities Division, Environment Canada.
9. Food and Agriculture Organization of the United Nations, 2013, *FAOSTAT, Resources, Fertilizers*, *http://faostat3.fao.org/faostat-gateway/go/to/home/E* (accessed April 16, 2014).
10. An industrial process to produce ammonia from nitrogen and hydrogen.
11. The interaction between two different organisms living in close physical association, typically to the advantage of both.
12. Cordell, D. and T.-S.S. Neset, 2014, "Phosphorus vulnerability: A qualitative framework for assessing the vulnerability of national and regional food systems to the multi-dimensional stressors of phosphorus scarcity," *Global Environmental Change*, Vol. 24, pages 108 to 122.

2.1 Farmland in Canada

According to the Food and Agriculture Organization of the United Nations (FAO), more than a third of total land area worldwide is used for agriculture (Table 2.1). Further, an estimated 28% of this agricultural area is arable—considered suitable for crop production. Arable land is an important element of ecological infrastructure supporting agriculture.

Despite the fact that arable land accounts for a small percentage of the country's total land area, Canada ranks seventh in the world for arable land. About 7% of the total land area of Canada is used for agriculture, more than two-thirds of which is arable land. Statistics Canada's agricultural ecumene identifies the areas of the country where agricultural activity is located (Map 2.1).[13]

13. Statistics Canada, 2012, *Agricultural Ecumene Boundary File: Reference Guide, 2011 Census of Agriculture*, Catalogue no. 92-639-G.

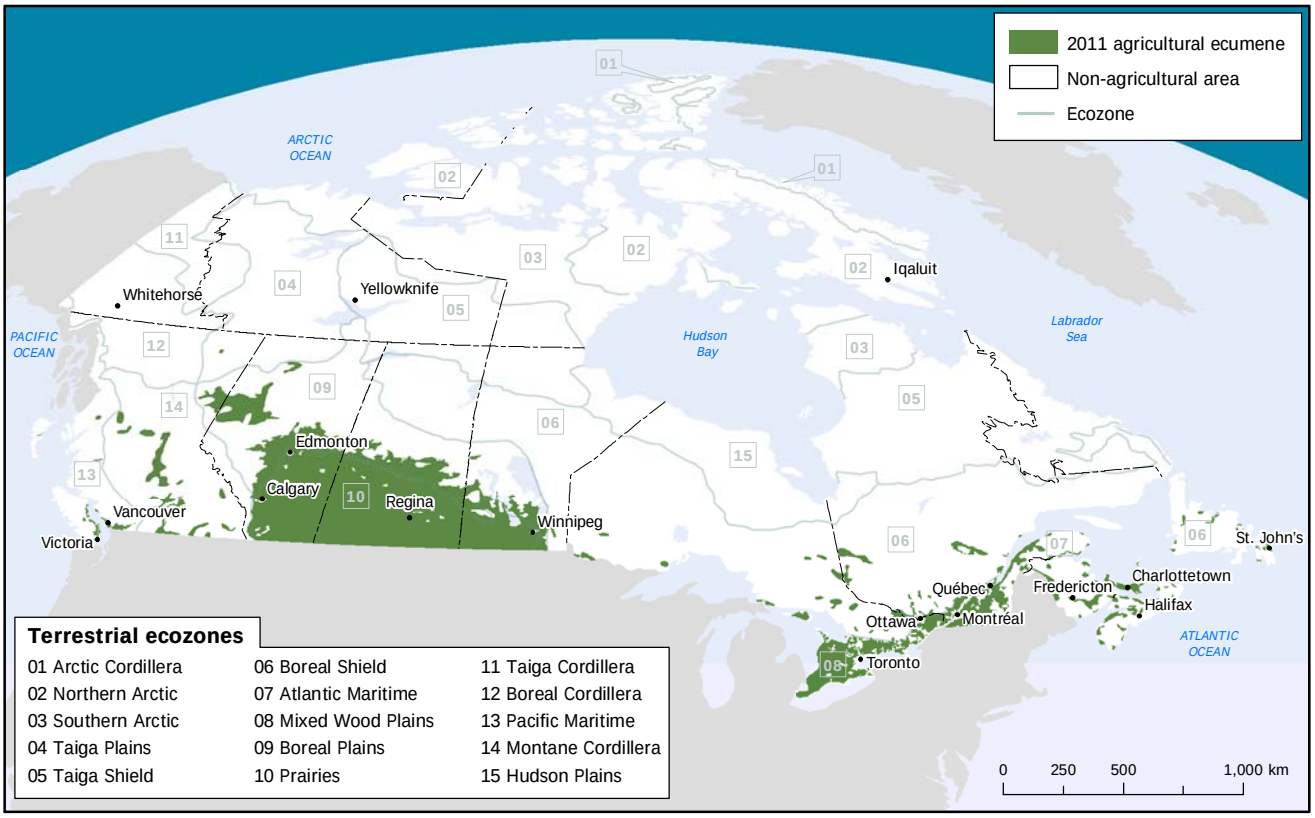
Table 2.1
Global availability of agricultural and arable land in 2011

	Land area[1]	Agricultural area[2]	Arable land	Percentage of land used for agriculture	Percentage of agricultural area that is arable	Global rank for arable land area
	thousands of hectares			percent		number
World	**13,003,420**	**4,911,623**	**1,396,280**	**38**	**28**	**...**
United States of America	914,742	411,263	160,163	45	39	1
India	297,319	179,799	157,350	60	88	2
Russian Federation	1,637,687	215,250	121,500	13	56	3
China	932,749	519,148	111,599	56	21	4
Brazil	845,942	275,030	71,930	33	26	5
Australia	768,230	409,673	47,678	53	12	6
Canada	909,351	62,597	42,968[3]	7	69	7
Argentina	273,669	147,548	38,048	54	26	8
Nigeria	91,077	76,200	36,000	84	47	9
Ukraine	57,932	41,281	32,499	71	79	10

1. Land area is the total area of the country excluding inland water bodies.
2. Agricultural area is the sum of areas under arable land—land under temporary crops; permanent crops—land cultivated with long-term crops, trees and shrubs producing flowers, and nurseries; and permanent meadows and pastures—land used permanently to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land). The agricultural area for Canada is calculated as the total farm area reported on the 2011 Census of Agriculture, minus the land use category 'All other land.'
3. The arable land category for Canada sums data from the 2011 Census of Agriculture for the categories 'Cropland, ''Summerfallow' and 'Tame or seeded pasture.'

Source(s): Food and Agriculture Organization of the United Nations, 2013, *FAOSTAT, Resources, Land Use Database*, *http://faostat.fao.org/site/291/default.aspx* (accessed December 23, 2013).

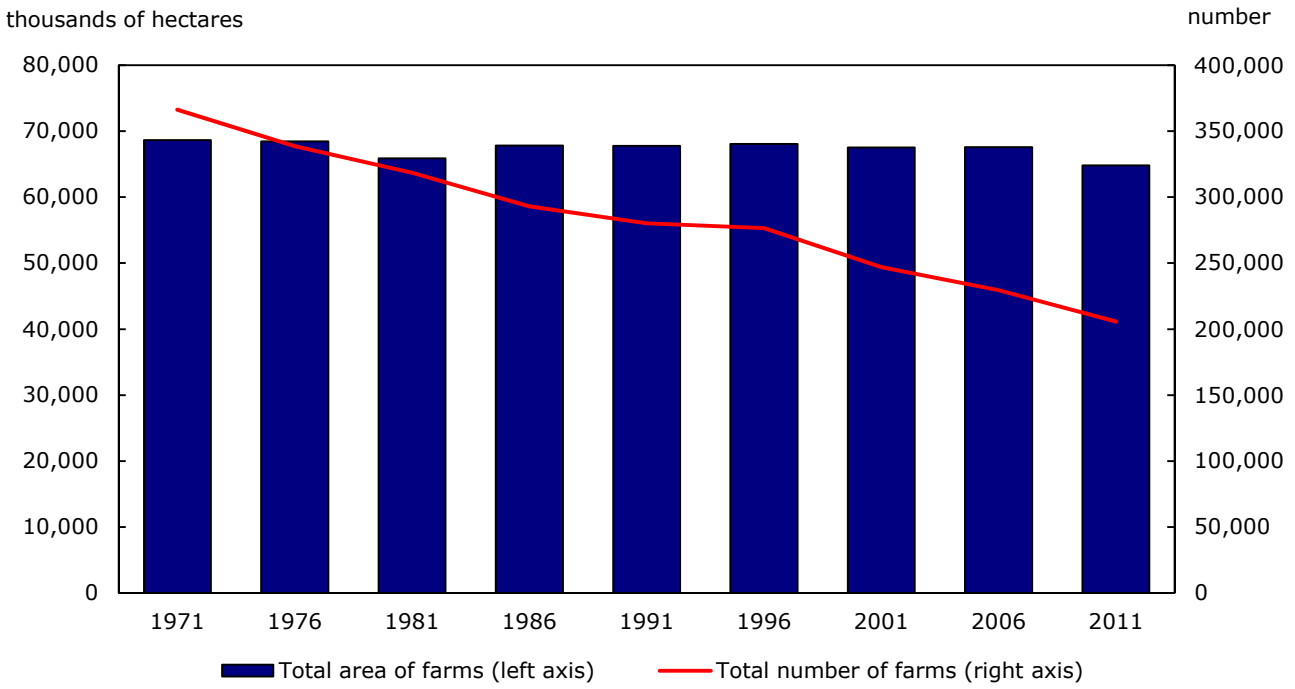
Map 2.1
Canada's agricultural ecumene, 2011



Source(s): Statistics Canada, 2012, *Agricultural Ecumene Boundary File, 2011 Census of Agriculture*, Catalogue no. 92-639-X

Farm area in Canada declined (-6%) from 68.7 million hectares in 1971 to 64.8 million hectares in 2011 (Chart 2.1). The loss of 3.9 million hectares of farm area is equal to an area approximately the size of Vancouver Island in British Columbia. The number of farms in Canada, meanwhile, dropped 44% from 366,110 farms to 205,730 farms. As a result, the average farm has increased in size from 188 hectares to 315 hectares.

Chart 2.1
Total farm area and number of farms in Canada, 1971 to 2011



Source: Statistics Canada, CANSIM table 004-0001 (accessed March 14, 2014).

In 2011, 62% (40.1 million hectares) of Canada's total farm area was located in the Prairies ecozone,[14] 20% (12.9 million hectares) was found in the Boreal Plains, 10% (6.2 million hectares) in the Mixed Wood Plains, 3% in both the Montane Cordillera (1.7 million hectares) and Atlantic Maritime (2.1 million hectares), 2% in the Boreal Shield (1.4 million hectares) and very small percentages in both the Taiga Plains and Pacific Maritime ecozones (Chart 2.2 and Table 2.2).

The largest decreases in farm area from 1971 to 2011 occurred in the Mixed Wood Plains (-1.3 million hectares), Prairies (-1.3 million hectares) and Atlantic Maritime ecozones (-732,826 hectares). The largest increase in farm area occurred in the Boreal Plains (+627,783 hectares). In terms of percent change though, the Montane Cordillera saw a noteworthy 41% increase over this period.

14. For geographic coverage, please see Map *1*, Appendix H in Statistics Canada, 2013, "Measuring ecosystem goods and services in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X.

Agricultural activity was most heavily concentrated in the Prairies ecozone in 2011, with 86% of the total ecozone area being farmed (Table 2.2). In comparison, 37% of the Mixed Wood Plains and 17% of the Boreal Plains ecozones were farmed. At the ecodistrict level, farms occupy more than 75% of the total land area for many ecodistricts in the Prairies ecozone, as well as some ecodistricts in the Mixed Wood Plains and Boreal Plains ecozones (Map 2.2). See Textbox 3 for more information on agriculture in the Prairies and Mixed Wood Plains.

Textbox 3: Agricultural profile of the Prairies and Mixed Wood Plains ecozones

The Prairies and Mixed Wood Plains ecozones are two important farming areas in Canada. Together they accounted for almost two-thirds of farms and almost three-quarters of farm area in Canada in 2011.

Prairies

The Prairies ecozone stretches from the Rocky Mountains in Alberta to the Red River valley in Manitoba, covering the southern third of the Prairie provinces. In 2011, 33% of all farms in Canada were located in the Prairies ecozone. Farm area made up 86% of the total ecozone area at 40.1 million hectares. Cropland—land producing field crops, hay, fruit, vegetables, sod and nursery crops—accounted for more than half of total farm area.

Wheat, canola and beef are the foundation of farming in the Prairies ecozone. In 2011, farms in this ecozone accounted for 80% of the area of wheat, 81% of the area of canola and 59% of the inventory of beef cattle in Canada. Herbicides were applied to 18.3 million hectares of farmland in the ecozone, insecticides to 1.8 million hectares and fungicides to 4.0 million hectares in 2010. Livestock in this ecozone produced over 68 million tonnes of manure, almost half of the national total in 2011.

Mixed Wood Plains

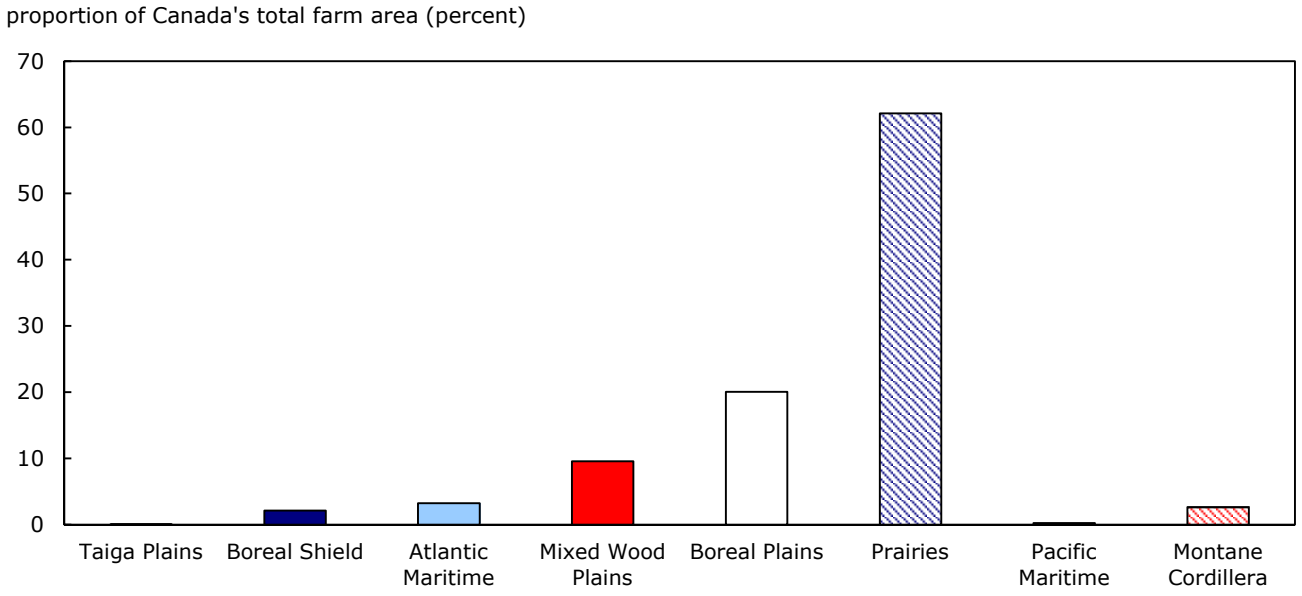
The Mixed Wood Plains ecozone is bounded by three Great Lakes—Lake Ontario, Lake Erie and Lake Huron—in the south and extends along the St. Lawrence River to Quebec City. This is the smallest Canadian ecozone.

In 2011, 31% of all farms in Canada were located in the Mixed Wood Plains ecozone. Farm area made up 37% of the ecozone area at 6.2 million hectares. Cropland accounted for close to three-quarters of total farm area.

There are many different types of farms in the Mixed Wood Plains ecozone. Farms in this ecozone accounted for 91% of the grain corn and 71% of the soy beans seeded in the country, and accounted for more than half of the Canadian inventories of dairy cattle, poultry and pigs in 2011. Herbicides were applied to 3.1 million hectares of farmland in the ecozone, insecticides to 539,004 hectares and fungicides to 446,581 hectares in 2010. Livestock produced almost 36.1 million tonnes of manure in 2011.

Source(s): Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011.

Chart 2.2
Distribution of farm area in Canada, by ecozone, 2011



Source: Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011.

In 2011, farm area per capita was highest in the Boreal Plains (14,971 hectares/1,000 people) and the Prairies (8,116 hectares/1,000 people) (Table 2.2), where much of agricultural production focused on small grains and oilseeds for export. Farm area per capita dropped by 43% in the Prairies and by 48% in the Mixed Wood Plains ecozones from 1971 to 2011.

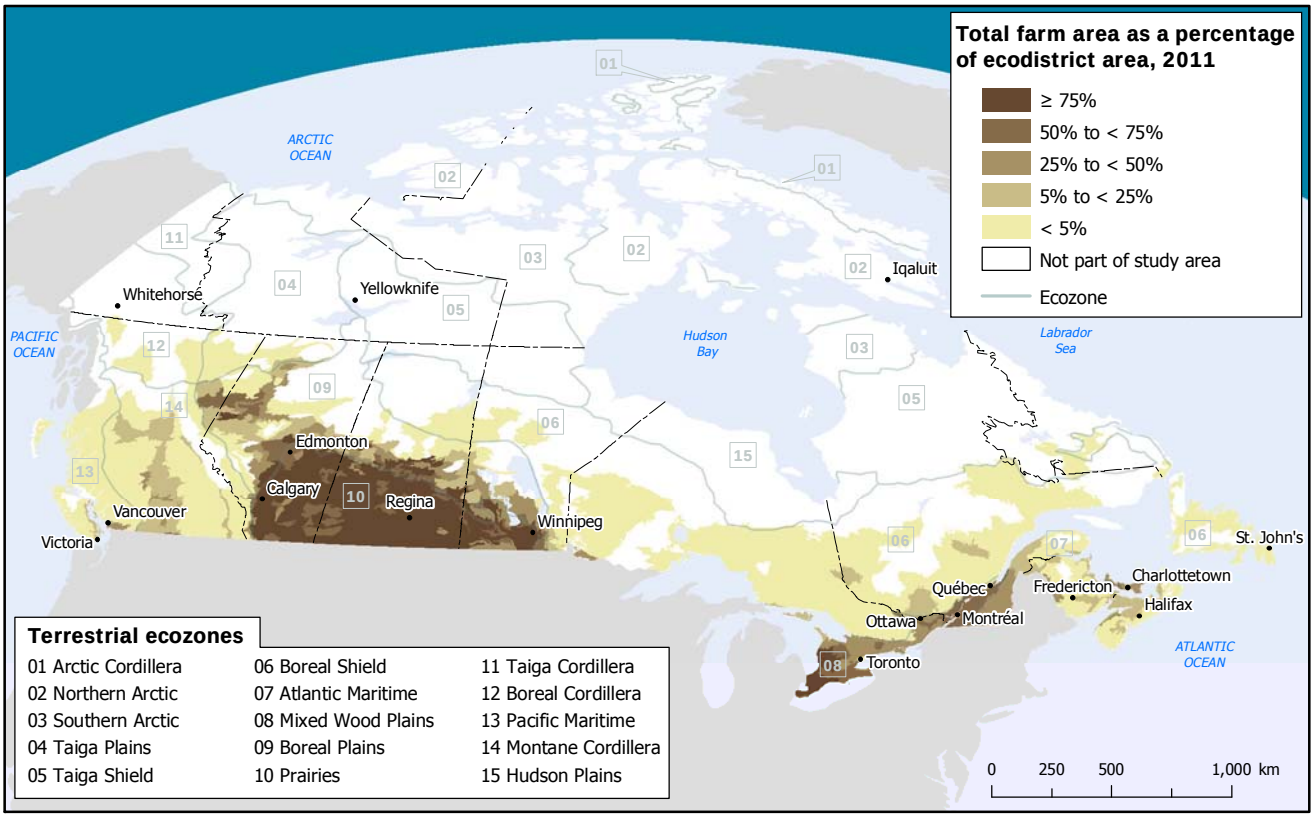
Table 2.2
Farm area in Canada by ecozone, 1971 and 2011

	Ecozone area [1]	Farm area [2]			Farm area as a proportion of ecozone area		Farm area per capita [3]	
		1971	2011	Change 1971 to 2011	1971	2011	1971	2011
	hectares			percent			hectares per thousand people	
Canada total	**997,621,635**	**68,660,645**	**64,812,723**	**-5.6**	**6.9**	**6.5**	**3,183**	**1,936**
Taiga Plains	65,777,768	0	8,390	.	0.0	0.0	0	364
Boreal Shield	191,822,190	1,894,746	1,362,344	-28.1	1.0	0.7	750	461
Atlantic Maritime	20,131,020	2,806,095	2,073,269	-26.1	13.9	10.3	1,234	797
Mixed Wood Plains	16,848,607	7,504,815	6,167,667	-17.8	44.5	36.6	680	351
Boreal Plains	74,302,776	12,311,291	12,939,074	5.1	16.6	17.4	21,924	14,971
Prairies	46,659,208	41,341,285	40,067,118	-3.1	88.6	85.9	14,176	8,116
Pacific Maritime	20,857,208	148,121	158,831	7.2	0.7	0.8	90	46
Montane Cordillera	48,747,704	1,205,697	1,705,238	41.4	2.5	3.5	2,370	1,874

1. The national total for ecozone area does not equal the sum of ecozones presented, since this table only includes ecozones with agricultural activity.
2. Any differences between the results by ecozone and national totals are due to data suppression to protect confidentiality. See Statistics Canada, 2008, *Census of Agriculture: Environmental Geography Aggregations of Census Farm Units* (survey number 8012) for further details.
3. The population used for the national calculation of farm area per capita does not equal the sum of the population of the ecozones presented, since this table only includes ecozones with agricultural activity.

Source(s): Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011 and Census of Agriculture Regular Base 1971. Statistics Canada, CANSIM tables 153-0057 (accessed January 9, 2011) and 004-0001 (accessed May 8, 2014). Statistics Canada, 2012, *Population and Dwelling Count Highlight Tables, 2011 Census*, Catalogue no. 98-310-X. Statistics Canada, Environment, Energy and Transportation Statistics Division, 2014, special tabulation.

Map 2.2
Total farm area as a percentage of ecodistrict area, 2011



Source(s): Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011. Statistics Canada, Environment, Energy and Transportation Statistics Division, 2014, special tabulation.

2.1.1 Dependable agricultural land

Not all land is suitable for agriculture–crop production depends on the right combination of soil, climate, water and other factors. In Canada, land has been classified into seven classes according to its suitability for agriculture.[15]

Class 1 land has no significant limitations for crop production, while Class 2 and 3 lands have moderate or moderately severe limitations that restrict the range of crops or require conservation practices. Together, these three categories indicate lands that are suitable for long term cultivation,[16] and have been termed 'dependable agricultural land.'[17] Lands in classes 4 to 6 have important limitations for crops and/or forage crops, while land in Class 7 is not suitable for cropping or permanent pasture.

Canada has over 50.5 million hectares of dependable (Class 1 to 3) agricultural land (Table 2.3). Most of this dependable agricultural land is found in the Prairies (26.0 million hectares) and Boreal Plains (10.8 million hectares) ecozones. Land with important limitations for

15. The Canada Land Inventory (CLI) assessed the climate and soil characteristics of mineral soils in order to evaluate the limitations for field crop production. The potential capability of soils was emphasized over the existing land use. Note that the CLI Soil Capability Classification for Agriculture does not cover the entirety of the country.

16. Environment Canada, 1972, *Canada Land Inventory: Soil Capability Classification for Agriculture,* Report no. 2, Catalogue no. F063-2/1972.

17. Dependable agricultural land (Class 1 to 3) represents land with a high capability for sustained cultivated crop production. Class 4 land is marginal for crop production and requires the use of additional management or conservation practices, Class 5 is capable of permanent pasture and hay, Class 6 is suitable for natural pasture, and Class 7 is not suitable for cropping or permanent pasture. Environment Canada, 1972, *Canada Land Inventory: Soil Capability Classification for Agriculture,* Report no. 2, Catalogue no. F063-2/1972.

agriculture (Class 4 to 6) can also be found in each ecozone.

The farm area located on dependable agricultural land, which includes the very best agricultural Class 1 land, has declined by 969,802 hectares from 2001 to 2011. The three ecozones with the most dependable agricultural land all saw declines in farm area (Table 2.3), namely the Prairies, the Boreal Plains and the Mixed Wood Plains over this period.

Conversely, farm area increased on land with important limitations for agriculture in the Montane Cordillera, Prairies, Atlantic Maritime, Boreal Shield, and Pacific Maritime ecozones. This land is subject to important limitations restricting the range of crops that can be grown and requiring significant conservation or improvement practices. Clearing, draining, diking, irrigation, stone removal and intensive addition of fertilizers and other soil amendments can all require costly expenditures.

Meanwhile, settled area[18] on dependable agricultural land in Canada increased by 19% from 2000 to 2011 (Table 2.3). By ecozone, the largest increase occurred in the Mixed Wood Plains, where the settled area on dependable agricultural land grew by 128,030 hectares (+27%)—over half this growth came from the Greater Golden Horseshoe.[19] The second largest increase was noted in the Prairies ecozone, where settled area on dependable agricultural land increased 59,807 hectares (+16%).

As Canada's population grows and cities develop and spread outward, the loss of some of the country's best farmland will likely continue given that many population centres are located near some of the best farmland in the country, due to historical patterns of development.[20]

18. Settled area is based on Agriculture and Agri-Food Canada's (AAFC) 30 m land cover code for developed areas. Some northern areas only partially covered by the AAFC land cover (see Map *1*, Appendix C in Statistics Canada, 2013, "Measuring ecosystem goods and services in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X for geographic coverage) were supplemented with estimates derived from Statistics Canada's settlements data and AAFC's 30 m land cover.
19. The Greater Golden Horseshoe is a 33,200 km^2 area located to the west of Lake Ontario including the Greater Toronto Area. Please see Map *3.2* Statistics Canada, 2013, "Measuring ecosystem goods and services in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X.
20. Wang, J., 2004, "They're tilling that field behind the mall," *Canadian Agriculture at a Glance*, Statistics Canada Catalogue no. 96-325-X.

Table 2.3
Farm area and settled areas in relation to Canada Land Inventory, by ecozone

	Dependable agricultural land [1]	Land with important limitations for agriculture [2]	Farm area on dependable agricultural land		Farm area on land with important limitations for agriculture		Settled area on dependable agricultural land [3]	
			2001	2011	2001	2011	2000	2011
	hectares							
Total	**50,534,922** [4]	**74,413,254**	**36,796,533**	**35,826,731**	**23,410,939**	**23,772,487**	**1,173,824** [5]	**1,393,335**
Taiga Plains	35,776	1,623,948	48	469	1,562	1,422	10	10
Boreal Shield	2,705,419	8,193,591	378,384	368,866	314,973	345,454	68,986	73,226
Atlantic Maritime	3,746,182	5,942,430	624,649	668,190	693,864	754,836	135,137	145,673
Mixed Wood Plains	6,991,637	2,812,461	4,567,559	4,360,662	1,297,333	1,242,348	479,923	607,953
Boreal Plains	10,783,663	26,807,321	6,980,387	6,746,594	4,784,293	4,721,428	93,584	103,972
Prairies	25,996,677	19,215,318	24,159,266	23,592,406	15,429,313	15,596,043	365,275	425,082
Pacific Maritime [6]	107,238	453,028	33,674	34,317	40,674	45,221	23,102	28,848
Montane Cordillera [6]	168,329	9,365,157	52,566	55,226	848,927	1,065,736	7,807	8,572

1. Dependable agricultural land is land designated as Class 1 (no significant limitations), Class 2 (moderate limitations) and Class 3 (moderately severe limitations) by the Canada Land Inventory and includes all evaluated land areas that are not affected by severe constraints for crop production.
2. Land with important limitations for agriculture is designated as Class 4 (severe limitations), Class 5 (forage crops improvement practices feasible), and Class 6 (forage crops improvement practices not feasible).
3. Settled area is based on Agriculture and Agri-Food Canada's (AAFC) 30 m land cover code for developed areas. Some northern areas only partially covered by the AAFC land cover were supplemented with estimates derived from Statistics Canada's settlements data and AAFC's 30 m land cover (see Map 1, Appendix C in Statistics Canada, 2013, "Measuring ecosystem goods and services in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X for geographic coverage).
4. Total dependable agricultural land presented here differs from that in Hofmann, N., G. Filoso and M. Schofield, 2005, "The loss of dependable agricultural land in Canada," *Rural and Small Town Canada Analysis Bulletin*, Statistics Canada Catalogue no. 21-006-X, Vol. 6, no. 1, due to differences in the projection selected and the reporting geography for the GIS analysis and the supplementary data sources.
5. Total settled area on dependable agricultural land presented here differs from that in Hoffman et al. (2005), due to the use of 2001 Census Enumeration Area (EA) files for the estimate of total settled area in Hoffman et al. (2005), while this study mainly used 2000 AAFC 30 m satellite imagery. See note 3 for further details.
6. Canada Land Inventory data for the categories dependable agricultural land and land with important limitations for agriculture have been supplemented with data from British Columbia's Agricultural Capability dataset (1:50,000) to address gaps in coverage.

Source(s): Agriculture and Agri-Food Canada, 1998, *Canada Land Inventory, National Soil DataBase*, *http://sis.agr.gc.ca/cansis/nsdb/cli/index.html* (accessed June 4, 2014). Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2001 and 2011. Agriculture and Agri-Food Canada, 2009, *Land Cover for Agricultural Regions of Canada (circa 2000),* version 12, *http://data.gc.ca/data/en/dataset/16d2f828-96bb-468d-9b7d-1307c81e17b8* (accessed October 9, 2012). Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). British Columbia Ministry of Environment, Environmental Stewardship Division, 2013, *Agriculture Capabilities geodatabase*, *www.env.gov.bc.ca/esd/distdata/ecosystems/Soil_Data/AgricultureCapability_50K/* (accessed June 4, 2014). Hofmann, N., A. Elgarawany, H. Larocque, G. Filoso and T. Dennis, 2010, "A new research project on Canadian settlements: initial geographic results," *EnviroStats*, Vol. 4, no. 1, Statistics Canada Catalogue no. 16-002-X.

2.2 Landscape type by ecozone

Land cover and land use influence ecosystem functions and consequently will affect the provision of ecosystem goods and services (EGS). Natural areas that are least disturbed by human activity—for example, forests, wetlands, grasslands, and shrublands—may be more able to maintain complex ecological functions than areas that have been significantly modified from the natural landscape. Farm area can be moderately to highly modified, while settled areas are normally highly modified from their natural state.

Between 2001 and 2011, the total farm area in Canada decreased 4% from approximately 67.5 million hectares to 64.8 million hectares; however, the trend varied by ecozone (Table 2.4). In some instances, land was converted to settled areas; however, in others, land no longer farmed likely sat idle and may have begun to naturalize.[21]

In 2011, settled area was highest in the Mixed Wood Plains ecozone at nearly 892,000 hectares, which represented 5% of the total ecozone area. Settled area increased by 20% or 150,000 hectares from 2001 to 2011 in the Mixed Wood Plains ecozone, while farm area dropped by approximately 4% or 289,000 hectares and natural and naturalizing area increased 1% (+138,000 hectares). In the Prairies ecozone, settled area increased 15% (+88,000 hectares).

21. Naturalizing landscapes have previously been modified from their natural state, but have been left undisturbed and are transitioning to a more natural land cover (e.g., cleared land reverting to wooded land). The new natural state may or may not be similar to the original land cover.

The Prairies and Mixed Wood Plains ecozones have relatively low proportions of natural areas—which could impact the range and quality of EGS, such as habitat provision, that are provided in these areas.

Table 2.4
Landscape type by ecozone, 2001 and 2011

	Ecozone area		Settled area [1]	Farm area [2]	Natural and naturalizing area [3]	Settled area [1]	Farm area [2]	Natural and naturalizing area [3]
			2001 [4]			2011		
	thousands of hectares	percent water	thousands of hectares					
Total	**485,146**	**11.4**	**2,710**	**67,502**	**414,934**	**3,060**	**64,813**	**417,274**
Taiga Plains	65,778	13.4	5	5	65,767	5	8	65,764
Boreal Shield	191,822	14.4	485	1,295	190,043	501	1,362	189,959
Atlantic Maritime	20,131	4.5	355	1,929	17,847	383	2,073	17,675
Mixed Wood Plains	16,849	35.7	741	6,456	9,651	892	6,168	9,789
Boreal Plains	74,303	9.7	220	13,229	60,854	246	12,939	61,118
Prairies	46,659	5.0	582	40,340	5,737	671	40,067	5,921
Pacific Maritime	20,857	5.3	188	149	20,521	218	159	20,480
Montane Cordillera	48,748	3.0	134	1,294	47,320	144	1,705	46,898

	Settled area [1]	Farm area [2]	Natural and naturalizing area [3]	Settled area [1]	Farm area [2]	Natural and naturalizing area [3]	Settled area [1]	Farm area [2]	Natural and naturalizing area [3]
	Change 2001 to 2011 [4]						2011		
	thousands of hectares			percent			percent of total area		
Total	**350**	**-2,690**	**2,340**	**12.9**	**-4.0**	**0.6**	**0.6**	**13.4**	**86.0**
Taiga Plains	0	3	-3	0.6	58.1	0.0	0.0	0.0	100.0
Boreal Shield	16	68	-84	3.4	5.2	0.0	0.3	0.7	99.0
Atlantic Maritime	28	145	-172	7.8	7.5	-1.0	1.9	10.3	87.8
Mixed Wood Plains	150	-289	138	20.3	-4.5	1.4	5.3	36.6	58.1
Boreal Plains	26	-290	264	11.7	-2.2	0.4	0.3	17.4	82.3
Prairies	88	-273	184	15.2	-0.7	3.2	1.4	85.9	12.7
Pacific Maritime	30	10	-40	16.2	6.7	-0.2	1.0	0.8	98.2
Montane Cordillera	11	411	-422	8.0	31.7	-0.9	0.3	3.5	96.2

1. Settled area is based on Agriculture and Agri-Food Canada's (AAFC) 30 m land cover code for developed areas. Some northern areas only partially covered by the AAFC land cover were supplemented with estimates derived from Statistics Canada's population and settlements data and AAFC's 30 m land cover (see Map 1, Appendix C in Statistics Canada, 2013, "Measuring ecosystem goods and services in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X for geographic coverage).
2. The total for farm area is a national total and is represented by the variable 'total farm area' from the Census of Agriculture. Any differences between the results by ecozone and national totals are due to data suppression to protect confidentiality. See Statistics Canada, 2008, *Census of Agriculture: Environmental Geography Aggregations of Census Farm Units* (survey number 8012) for further details.
3. Natural and naturalizing land area is calculated as the residual landscape of the ecozone that is not settled or used for agriculture.
4. Data presented for Settled area are for 2000; Change for Settled area is from 2000 to 2011.

Source(s): Statistics Canada, Environment, Energy and Transportation Statistics Division, 2014, special tabulation. Agriculture and Agri-Food Canada, 2009, *Land Cover for Agricultural Regions of Canada (circa 2000)*, version 12, *http://data.gc.ca/data/en/dataset/16d2f828-96bb-468d-9b7d-1307c81e17b8* (accessed October 9, 2012). Agriculture and Agri-Food Canada, 2012, *2011 AAFC Crop Type Map of Canada*, *ftp://ftp.agr.gc.ca/pub/outgoing/aesb-eos-gg/Crop_Inventory/2011/* (accessed October 9, 2012). Statistics Canada, CANSIM table 004-0001 (accessed May 8, 2014). Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2001 and 2011.

Section 3

Ecosystems goods and services from agriculture

Agricultural ecosystems produce many goods and services that provide benefits for human well-being. These ecosystem goods and services (EGS) can include the outputs of farm production—food, fibre and fuel—as well as other products, although discussion continues on how exactly to define and categorize individual services.[1] Agricultural land and activities can also contribute to the provision of regulating and cultural services.

The agricultural sector exemplifies how the economy is dependent on the availability of ecosystem services. The production of agricultural goods is dependent on many supporting services provided by ecosystems. Without nutrient cycling,[2] primary production,[3] pollination, soil moisture, and other services, agriculture and the benefits it provides to people would not be possible.

1. Many of these products result from the combination of ecosystem services and human inputs, such as labour and fertilizers. Please note that various approaches to classifying ecosystem services treat products differently when they result from joint production using both ecosystem services and human inputs. For example, while the *Millennium Ecosystem Assessment (MEA)*, *The Economics of Ecosystems and Biodiversity (TEEB), The Common International Classification of Ecosystem Services (CICES)* and other approaches equate the ecosystem services inherent in crops to the crops themselves (the harvest approach to measurement), the ecosystem accounting approach proposed by the *System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounting* considers ecosystem services to represent only the combination of ecosystem processes (e.g., pollination, nutrient cycling) that contribute to plant growth and would exclude the human inputs involved in this production.
2. Nutrient cycling is the movement of nutrients such as carbon, nitrogen and phosphorus through the environment.
3. Primary production is the production of organic matter from carbon dioxide, which occurs mainly as a result of photosynthesis.

3.1 Agricultural goods

Agricultural activities in Canada contribute to the production of many provisioning services including crops, livestock, milk, eggs and other products. At an international level, Canada ranked 10th in the world for cereal production, producing about 1.8% of global cereal crops, and ranked 11th for meat production, accounting for about 1.5% of worldwide production (Table 3.1).

Table 3.1
Food production in selected countries, 2010

	Cereals			Meat		
	Production	Share in world	Rank	Production	Share in world	Rank
	thousands of tonnes	percent	number	thousands of tonnes	percent	number
World	**2,476,416**	…	…	**296,107**	…	…
China	497,943	20.1	1	80,926	27.3	1
United States of America	401,670	16.2	2	42,168	14.2	2
India	267,838	10.8	3	6,180	2.1	6
Indonesia	84,797	3.4	4	2,849	1.0	19
Brazil	75,161	3.0	5	23,630	8.0	3
France	68,285	2.8	6	5,745	1.9	8
Russian Federation	59,624	2.4	7	7,214	2.4	5
Bangladesh	51,875	2.1	8	609	0.2	56
Argentina	47,146	1.9	9	4,698	1.6	10
Canada	45,651	1.8	10	4,458	1.5	11
Vietnam	44,614	1.8	11	3,988	1.3	13
Germany	44,314	1.8	12	8,220	2.8	4

Source(s): Food and Agriculture Organization of the United Nations, 2013, *FAO Statistical Yearbook 2013, World Food and Agriculture*, *www.fao.org/docrep/018/i3107e/i3107e00.htm* (accessed December 23, 2013).

The output from farm operations totaled more than 134 million tonnes in 2012, with farm cash receipts of $54.2 billion (Table 3.2 and 3.3).[4] By weight, food and fodder crops, such as wheat, canola, potatoes, fruit, vegetables and hay, account for 90% of the output of agriculture, followed by milk (6%) and livestock and poultry meat (4%) in 2012. As a proportion of farm receipts, however, food and fodder crops accounted for 51%, followed by livestock and poultry (25%), milk (11%), with eggs, maple and honey products, other crops, alternative livestock and livestock products and receipts from direct payments making up the remainder.

Agricultural production varies by region across the country. By weight, the Prairie provinces accounted for 63% of food and fodder crop production in 2012; Quebec, Ontario and Alberta accounted for 75% of livestock and poultry meat production; and Quebec and Ontario accounted for 70% of milk production and 55% of egg production. Farm cash receipts were split almost evenly between Ontario (23%), Alberta (22%) and Saskatchewan (22%), followed by Quebec (15%) and Manitoba (10%).

4. Output by weight excludes the production of flowers, sod, nursery products, Christmas trees, tobacco and timber, due to difficulties in estimating the weight of production or lack of data. The value of these items is included in farm cash receipts. See detailed table notes for more information.

Table 3.2
Goods production from agriculture and aquaculture, 2012

	Food and fodder crops [1]	Livestock and poultry meat [2]	Milk	Eggs	Maple products and honey [3]	Other [4]	Total agricultural production	Aquaculture [5]
	tonnes							
Canada, total	**120,749,406**	**5,200,468**	**8,211,327**	**448,927**	**88,393**	**6,951**	**134,705,472**	**173,252**
Newfoundland and Labrador	33,642	2,429	49,816	6,509	0	503	92,900	21,228
Prince Edward Island	1,667,199	13,708	106,918	2,238	83	278	1,790,425	24,637
Nova Scotia	708,920	17,074	182,024	14,022	332	3,050	925,421	8,238
New Brunswick	1,251,932	9,176	143,164	11,636	2,182	119	1,418,209	31,481
Quebec	12,641,796	1,322,493	3,037,349	78,447	45,614	354	17,126,053	739
Ontario	25,098,038	1,447,003	2,697,753	168,246	5,635	1,352	29,418,026	3,700
Manitoba	13,845,025	552,324	346,388	57,405	5,989	63	14,807,194	x
Saskatchewan	32,757,844	329,465	238,906	19,902	10,492	126	33,356,736	x
Alberta	29,949,085	1,118,654	701,014	36,712	17,241	266	31,822,972	x
British Columbia	2,621,382	274,604	708,003	53,809	824	733	3,659,355	81,395

1. Includes the majority of grain, oilseed, pulse and hay, potato, vegetable, fruit, greenhouse vegetable and mushroom production. Mushroom data are included in the Canada total only.
2. Includes meat production in Canada of cattle, hog, poultry, sheep and lamb (warm carcass weight and edible offal). Excludes slaughter of imported animals. Hog data principally represents slaughter on a province of origin basis, but may include hogs destined for export (varies by province). Excludes other exports of live animals for slaughter. Excludes alternative livestock such as horse, bison, rabbit, deer and others.
3. Maple products are expressed as syrup.
4. Includes wool and fur-bearing animals (mink and fox). Excludes production of tobacco, sod, nursery, greenhouse flowers and Christmas trees.
5. Includes production of finfish and shellfish on sites, including some wild shellfish production. Excludes hatcheries and processing.

Note(s): Goods production from agriculture and aquaculture is based on crop and livestock surveys and represent the amount of organic material from living organisms that has been produced or extracted from ecosystems. These data are not a complete representation of all biomass (organic material) extraction from agriculture and aquaculture. Source data were not available for all crops, livestock and animal products. Manure production and some wastes and byproducts were excluded. Source data that were suppressed for confidentiality reasons or that were too unreliable to be published were treated as zeros. Some mathematical adjustments were performed to ensure comparability of results.

Source(s): Statistics Canada, CANSIM tables 001-0006, 001-0007, 001-0008, 001-0009, 001-0010, 001-0013, 001-0014, 003-0011, 003-0018 (accessed December 19, 2013), 001-0012 (accessed January 2, 2014), 003-0015, 003-0020, 003-0026, 003-0028, 003-0083, 003-0094, 003-0102 (accessed January 15, 2014), 003-0001 (accessed April 7, 2014) and 003-0097 (accessed April 11, 2014). Agriculture and Agri-Food Canada, 2012, *009D Average Warm Carcass Weights at Federally Inspected Plants*, *http://www3.agr.gc.ca/apps/aimis-simia/rp/index-eng.cfm?menupos=1.02.08&PARENT_DATA_CLCTN_TYPE_CODE=&REPORT_ID=135&ACTION=promptReport&LANG=EN* (accessed May 7, 2013). Agriculture and Agri-Food Canada, n.d. (no date), *Sheep Supply Canada: Year to Date for the Month Ending December, 2012*, *www.cansheep.ca/cms/en/Resources/Markets/MarketReports/MarketReports.aspx* (accessed January 15, 2014). Food and Agriculture Organization of the United Nations (FAO) and the Information Network on Post-harvest Operations (INPhO), 1998, "Chapitre 2 Laits d'animaux laitiers, "*Le lait et les produits laitiers dans la nutrition humaine*, *www.fao.org/docrep/t4280f/T4280F04.htm#Chapitre* (accessed August 14, 2013). United States Department of Agriculture, 1992, *Weights, Measures and Conversion Factors for Agricultural Commodities and Their Products*, Agricultural Handbook Number 697, Washington D.C. Fur Commission USA, 2011, *Mink biology*, *www.furcommission.com/farming/mink-biology/* (accessed April 17, 2014). Wikipedia, n.d. (no date), *Fox*, *http://en.wikipedia.org/wiki/Fox* (accessed April 17, 2014).

Table 3.3
Farm cash receipts and value of aquaculture production, 2012

	Food and fodder crops [1]	Livestock and poultry [2]	Milk	Eggs	Maple products and honey	Other [3]	Receipts from direct payments [4]	Total farm cash receipts	Aquaculture [5]
	thousands of dollars								
Canada, total	**27,607,704**	**13,291,678**	**5,917,152**	**880,229**	**465,988**	**2,584,158**	**3,442,403**	**54,189,310**	**825,457**
Newfoundland and Labrador	7,214	3,603	45,473	17,862	0	26,949	1,229	130,310	112,804
Prince Edward Island	311,679	37,853	75,862	5,057	669	9,134	20,830	480,974	38,494
Nova Scotia	108,563	30,069	127,906	35,378	2,143	168,753	9,630	582,245	52,234
New Brunswick	184,838	38,121	101,296	22,085	21,158	58,006	32,456	537,426	191,615
Quebec	2,101,516	2,527,823	2,188,799	141,301	276,190	343,960	769,312	8,348,901	2,856
Ontario	5,758,755	2,907,245	1,908,431	329,189	38,825	1,059,643	308,800	12,310,889	18,300
Manitoba	2,695,281	1,512,857	248,793	107,574	22,703	94,984	495,534	5,177,726	x
Saskatchewan	9,173,504	1,392,574	169,673	38,281	33,444	81,824	948,800	11,838,272	x
Alberta	6,360,958	3,946,102	520,665	70,407	63,162	219,254	769,425	11,950,619	x
British Columbia	905,394	678,416	530,255	113,094	7,694	483,331	86,387	2,831,948	399,625

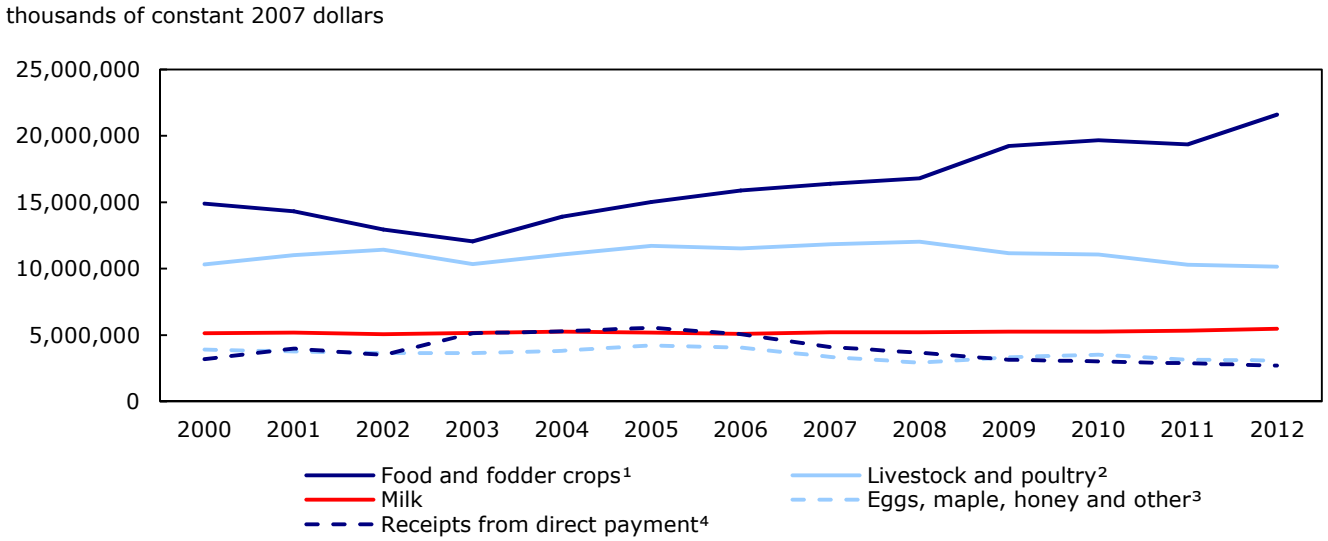
1. Includes farm cash receipts for crops including grain, oilseed, pulse, hay, potato, vegetable, fruit, greenhouse and mushroom production.
2. Includes farm cash receipts for cattle, hogs, poultry, sheep, lambs and hatchery chicks and poults. Excludes alternative livestock.
3. Includes farm cash receipts for tobacco, floriculture, nursery and sod, forest products, Christmas trees, wool, furs, miscellaneous livestock and livestock products (including wool, pregnant mare's urine, horses, embryos).
4. Includes crop insurance payments, private hail insurance, Agri-Invest, Agri-Stability, provincial stabilization and other payments and subsidies.
5. Includes the value of finfish and shellfish produced on sites, including some wild shellfish production. Excludes hatcheries and processing.

Note(s): The sum of parts may not equal the totals due to suppression of confidential data and data that is too unreliable to be published.
Source(s): Statistics Canada, CANSIM tables 002-0001 (accessed January 21, 2014) and 003-0001 (accessed April 7, 2014).

Agricultural production by weight was up over the period of 2000 to 2012.[5] Farm cash receipts (in 2007 constant dollars) increased 15% over the same period, largely due to increases in food and fodder crops (Chart 3.1).

5. See Table 3.2 for a complete list of sources.

Chart 3.1
Value of agricultural production, 2000 to 2012



1. Includes farm cash receipts for crops including grain, oilseed, pulse, hay, potato, vegetable, fruit, greenhouse and mushroom production.
2. Includes farm cash receipts for cattle, hogs, poultry, sheep, lambs and hatchery chicks and poults. Excludes alternative livestock.
3. Includes farm cash receipts for tobacco, floriculture, nursery and sod, forest products, Christmas trees, wool, furs, miscellaneous livestock and livestock products (including wool, pregnant mare's urine, horses, embryos).
4. Includes crop insurance payments, private hail insurance, Agri-Invest, Agri-Stability, provincial stabilization and other payments and subsidies.

Source: Statistics Canada, CANSIM tables 002-0001 and 002-0068 (accessed June 9, 2014).

Fish—perhaps the best known provisioning service of freshwater and marine and coastal ecosystems—can

Textbox 4: Aquaculture production

Aquaculture—the farming of marine and freshwater animals and plants in natural or artificial aquatic environments—shares certain similarities with land-based agriculture as it also depends heavily on ecosystem services to produce its output. Aquaculture is often contrasted with commercial fishing.

The Canadian aquaculture industry produced approximately 173,000 tonnes of fish and shellfish in 2012 (Table 3.2), compared to the 787,000 tonnes of fish and shellfish harvested in commercial fisheries.[6] Most aquaculture production in Canada occurs on the Atlantic and Pacific coasts. The total value of this production, an estimated $825 million (Table 3.3) was split almost equally between the two coasts in 2012.

The industry has grown significantly in recent decades, with production increasing 249% from 1991 to 2012.[7] In 2012, salmon accounted for 62% of aquaculture production, followed by mussels (16%), oysters (6%), and trout (4%).

Approximately 3,300 persons were directly employed in the aquaculture industry in 2013, compared to 17,200 persons employed in fishing.[8] Fisheries and Oceans Canada estimates that aquaculture also generates a large number of spin-off jobs in fish feed manufacturing, transportation and other related industries.[9]

Some of the main environmental issues faced by the industry include the impacts of excess feed on the ecosystem, the escape of farmed fish, disease and pests, and issues with organic waste, which are mitigated through appropriate aquaculture farm siting, escape prevention and other management activities.[10]

be captured and are increasingly farmed for human consumption (see Textbox 4).

3.2 Ecosystem services from agricultural landscapes and practices

In addition to their ability to provide food, agricultural landscapes are also valued for their potential to provide other ecosystem services,[11] such as carbon sequestration, the provision of wildlife habitat, recreational opportunities and scenic landscapes. Beneficial management practices are also increasingly used to reduce potential environmental impacts associated with agriculture and improve the provision of EGS.

3.2.1 Habitat

Agricultural ecosystems in Canada provide habitat for 588 species of birds, mammals, reptiles and amphibians.[12] These species rely on a variety of agricultural land types as habitat for breeding, feeding and other uses to varying degrees—some may be dependent on a specific type of agricultural land, while others are not.

From the perspective of wildlife, natural and semi-natural areas on farms such as woodland, wetland and riparian areas[13] provide the most valuable habitat, followed by natural pasture.[14] Three-quarters of species using agricultural land for habitat can use woodland, wetland and riparian areas for breeding and feeding requirements, while 29% use natural pasture land.[15] In 2011, woodlands and wetlands accounted for 8% of farm area, while natural pasture accounted for a further 23% (Table 3.4). Seeded or tame pasture, hay and various types of cropland can also be used by wildlife for breeding, feeding and other uses, but to a

6. Fisheries and Oceans Canada, 2014, *2012, Atlantic & Pacific Coasts Commercial Landings by Province*, *www.dfo-mpo.gc.ca/stats/commercial/land-debarq/sea-maritimes/s2012pq-eng.htm* (accessed May 8, 2014).
7. Statistics Canada, CANSIM table 003-0001 (accessed April 7, 2014).
8. Statistics Canada, Labour Force Survey, 2014, special tabulation.
9. Fisheries and Oceans Canada, 2012, *Aquaculture in Canada 2012: A Report on Aquaculture Sustainability,* Catalogue no. FS 45-1/2012E, *www.dfo-mpo.gc.ca/aquaculture/lib-bib/asri-irda/asri-irda-2012-eng.htm* (accessed April 10, 2014).
10. Fisheries and Oceans Canada, 2012.
11. Bowker, J.M. and D.D. Didychuk, 1994, "Estimation of the Nonmarket Benefits of Agricultural Land Retention in Eastern Canada," *Agricultural and Resource Economics Review*, Vol. 23, no. 2, pages 218 to 225.
12. Javorek, S.K. and M.C. Grant, 2011, "Trends in wildlife habitat capacity on agricultural land in Canada, 1986-2006," *Canadian Biodiversity: Ecosystem Status and Trends 2010*, Technical Thematic Report No. 14, Canadian Councils of Resource Ministers, Catalogue no. EN14-43/14-2011E-PDF, *www.biodivcanada.ca/default.asp?lang=En&n=137E1147-1* (accessed January 2, 2014).
13. Riparian areas border streams, rivers, lakes and wetlands.
14. Javorek, S.K. and M.C. Grant, 2011, "Trends in wildlife habitat capacity on agricultural land in Canada, 1986-2006," *Canadian Biodiversity: Ecosystem Status and Trends 2010*, Technical Thematic Report No. 14, Canadian Councils of Resource Ministers, Catalogue no. EN14-43/14-2011E-PDF, *www.biodivcanada.ca/default.asp?lang=En&n=137E1147-1* (accessed January 2, 2014).
15. Javorek, S.K. and M.C. Grant, 2011.

lesser extent—for example, only 13% of the species associated with agricultural land can meet their habitat requirements on cropland.[16]

Agriculture and Agri-Food Canada (AAFC) has assessed the habitat capacity of agricultural landscapes across the country. In 2006, farmland with high and very high habitat capacity was mostly found in Atlantic Canada and parts of Quebec, while land with very low and low habitat capacity was found mostly in the Prairies and southern Ontario and Quebec.[17] Areas with low habitat capacity were associated with a relatively small percentage of natural and semi-natural land in the agricultural landscape, and often agriculture was the dominant land use in the area.

16. Javorek, S.K. and M.C. Grant, 2011.
17. Javorek, S.K. and M.C. Grant, 2010, "Wildlife Habitat," pages 36 to 43 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.

Table 3.4
Natural areas on farms, 2011

	Natural land for pasture				Woodlands and wetlands			
	number of farms reporting	percent of farms	hectares	percent of farm area	number of farms reporting	percent of farms	hectares	percent of farm area
Canada	**82,865**	**40**	**14,703,330**	**23**	**102,744**	**50**	**4,897,367**	**8**
Newfoundland and Labrador	134	26	8,602	27	282	55	8,943	29
Prince Edward Island	428	29	9,230	4	1,047	70	46,690	19
Nova Scotia	1,271	33	25,148	6	2,658	68	218,825	53
New Brunswick	914	35	22,731	6	1,958	75	175,572	46
Quebec	7,653	26	134,147	4	21,415	73	1,057,417	32
Ontario	15,553	30	398,538	8	31,133	60	646,578	13
Manitoba	8,132	51	1,466,968	20	7,131	45	549,444	8
Saskatchewan	16,372	44	4,816,782	19	14,474	39	1,009,381	4
Alberta	23,855	55	6,435,825	31	16,051	37	893,436	4
British Columbia	8,553	43	1,385,359	53	6,595	33	291,079	11

Source(s): Statistics Canada, 2012, *Farm and Farm Operator Data, 2011 Census of Agriculture*, Catalogue no. 95-640-X.

Average national habitat capacity on agricultural land decreased from 1986 to 2006 as a result of reductions in natural and semi-natural land covers due to the intensification of agricultural operations.[18] The importance of these reductions in habitat capacity varies for different regions of the country, depending on whether the surrounding landscape contains natural and semi-natural land that is suitable for habitat.

Most agricultural crops rely on pollination in order to set fruit and seed. While major cereal crops including wheat, corn, rye, barley and oats are pollinated by wind, pollination by bees and other insects, birds, bats or other animals is required or can improve yields for most fruit, vegetable, forage and oilseed crops.[19] Natural areas within and around agricultural landscapes provide important habitat for wild pollinators. Greater distances from semi-natural and natural areas have been associated with reduced pollination and yields.[20,21] A recent study for Environment Canada showed that a 50% reduction in wild pollination could result in an annual loss of an estimated $53 million in the value of Canadian fruit production.[22]

As well, 3,272 farms in Canada reported owning honeybees for honey production or pollination, while 737 reported owning other pollinating bees, such as alfalfa leafcutters, bumblebees or blue orchard bees in 2011.[23] Farmers often rent these bees to help improve pollination of alfalfa, cranberries, greenhouse

18. Javorek, S.K. and M.C. Grant, 2010.
19. Natural Science and Engineering Research Council Canadian Pollination Initiative (NSERC-CANPOLIN), 2012, *Best Management Practices for Pollination in Ontario Crops, www.uoguelph.ca/canpolin/* (accessed February 4, 2014).
20. Ricketts, T.H., J. Regetz, I. Steffan-Dewenter, S.A. Cunningham, C. Kremen, A. Bogdanski, B. Gemmill-Herren, S.S. Greenleaf, A.M. Klein, M.M. Mayfield, L.A. Morandin, A. Ochieng', and B.F. Viana, 2008, "Landscape effects on crop pollination services: are there general patterns?" *Ecology Letters*, Vol. 11, Issue 5, pages 499 to 515.
21. Garibaldi, L.A., I. Steffan-Dewenter, C. Kremen, J.M. Morales, R. Bommarco, S.A. Cunningham, L.G. Carvalheiro, N.P. Chacoff, J.H. Dudenhöffer, S.S. Greenleaf, A. Holzschuh, R. Isaacs, K. Krewenka, Y. Mandelik, M.M. Mayfield, L.A. Morandin, S.G. Potts, T.H. Ricketts, H. Szentgyörgyi, B.F. Viana, C. Westphal, R. Winfree and A.M. Klein, 2011, "Stability of pollination services decreases with isolation from natural areas despite honey bee visits," *Ecology Letters*, Vol. 14, Issue 10, pages 1062 to 1072.
22. DSS Management Consultants Inc., 2010, *Valuation of Ecological Goods and Services in Canada's Natural Resource Sectors*, Technical report submitted to Ecosystems and Biodiversity Priorities Division, Environment Canada, *www.biodivcanada.ca/default.asp?lang=En&n=54B96EDA-1* (accessed June 3, 2014).
23. Statistics Canada, 2012, *Farm and Farm Operator Data, 2011 Census of Agriculture*, Catalogue no. 95-640-X.

tomatoes and other crops. Further, these other bees were reported almost exclusively in the three Prairie provinces.[24]

3.2.2 Water regulation and purification, soil conservation and climate regulation

The ability of agricultural ecosystems to provide various regulating and supporting services depends on landscape characteristics, as well as specific agricultural practices. For example, the presence of wetlands, small dams and land covers that retain water, slow runoff or encourage water infiltration into soils can help reduce peak streamflow and flooding. Wetlands and riparian buffer zones[25] can also improve water quality by helping to filter and trap soil, nutrients and pollutants before they enter streams, rivers or lakes, while windbreaks and shelterbelts can reduce soil erosion. Use of soil conservation practices such as reduced or no-till and cover cropping can also help reduce soil erosion, improve water quality and sequester carbon in soils.

24. Statistics Canada, 2012, "Snapshot of Canadian agriculture," *Farm and Farm Operator Data, 2011 Census of Agriculture*, Catalogue no. 95-640-X.
25. Riparian buffer zones are areas along natural watercourse or water body, left or planted with natural vegetation to prevent erosion, protect water quality and preserve wildlife habitat.
26. Canadian Dam Association, n.d. (no date), *Dams in Canada*, *www.imis100ca1.ca/CDA/Dams_in_Canada.aspx* (accessed January 6, 2014).

While there were 933 large dams in Canada in 2002, only 51 were used solely for irrigation.[26] However, there are thousands more small dams, many built to support irrigation in western Canada.[27] While there are environmental impacts associated with dams, they can also provide important benefits. A study of the South Tobacco Creek watershed in south-central Manitoba showed that small earthen dams and reservoirs on farms can reduce peak streamflow and flooding as well as sediment, nitrogen and phosphorus runoff into streams.[28]

Overall, 21% of farms had riparian buffer zones to protect water bodies and 30% of farms had windbreaks or shelterbelts in 2011 (Table 3.5). The proportion of farms with riparian buffers was highest in Prince Edward Island, which can be partly explained by regulatory requirements.[29] Windbreaks or shelterbelts were most common in Prince Edward Island, Manitoba and Alberta.

27. Environment Canada, 2010, *Dams & Diversions*, *www.ec.gc.ca/eau-water/default.asp?lang=En&n=9D404A01-1* (accessed August 21, 2014).
28. Agriculture and Agri-Food Canada, 2013, *Positive Effects of Small Dams and Reservoirs: Water quality and quantity findings from a Prairie Watershed*, Watershed Evaluation of Beneficial Management Practices (WEBs) Fact Sheet # 7, *www.agr.gc.ca/eng/?id=1351881784186* (accessed January 6, 2014).
29. Prince Edward Island Department of Environment, Labour and Justice, 2013, *Buffer Zones*, *http://www.gov.pe.ca/environment/buffer-zones* (accessed July 23, 2014).

Table 3.5
Windbreaks or shelterbelts and riparian buffer zones, 2011

	Windbreaks or shelterbelts (natural or planted)		Riparian buffer zones around water bodies	
	number of farms reporting	percent of farms	number of farms reporting	percent of farms
Canada	**61,024**	**30**	**42,566**	**21**
Newfoundland and Labrador	154	30	128	25
Prince Edward Island	614	41	800	54
Nova Scotia	739	19	905	23
New Brunswick	532	20	526	20
Quebec	5,908	20	8,755	30
Ontario	14,622	28	12,168	23
Manitoba	6,306	40	2,770	17
Saskatchewan	11,306	31	5,111	14
Alberta	16,985	39	8,236	19
British Columbia	3,858	20	3,167	16

Source(s): Statistics Canada, 2012, *Farm and Farm Operator Data, 2011 Census of Agriculture*, Catalogue no. 95-640-X.

AAFC has developed a soil organic carbon change indicator which provides an estimate of how much carbon dioxide is removed from the atmosphere and sequestered in agricultural soils.[30] Soil organic carbon is influenced by land management practices such as

30. McConkey, B.G., D. Cerkowniak, W.N. Smith, R.L. Desjardins and M.J. Bentham, 2010, "Soil Organic Matter," pages 54 to 60 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.

tillage,[31] summerfallow,[32] cover cropping[33] and use of animal and green manures.[34]

Overall, soil organic carbon retention has improved from the mid 1980s to 2006 as a result of farm management practices such as reductions in the use of conventional tillage and summerfallow.[35] These changes have resulted in cropland becoming a net sink[36] for atmospheric carbon dioxide. In 2012, the net storage of greenhouse gases in cropland was 5 megatonnes carbon dioxide equivalent (Mt CO_2 eq).[37] Increased soil organic matter also improves soil structure and fertility, resulting in better overall soil health. However, soil organic matter declined in central and Atlantic Canada as a result in changes from hay and pasture land to annual crops.[38]

3.2.3 Cultural services

Although farmland is normally privately owned, Canadians benefit from the many opportunities to enjoy the scenic views provided by agricultural landscapes and pursue recreation, tourism and education opportunities on farms.

As a result of historic settlement patterns, many agricultural areas are located near cities and towns, providing opportunities for families to harvest pumpkins at the pumpkin patch, enjoy pancakes with maple syrup at the local sugar shack, or learn about farm animals at petting zoos.

In Quebec, 837 farm operations provided agri-tourism opportunities in 2012, up 57% from 534 in 2005.[39] Other farms and businesses provide related services, such as farm gate sales, U-pick operations, as well as food processing activities (e.g., artisanal cheese and bread production) or farm stays. Canada's wine regions bring visitors from near and far and are becoming increasingly important tourist attractions. A recent study estimated 3.0 million tourists visited Canadian wineries in 2011.[40]

People in areas that are largely agricultural may also benefit from a sense of community identity and shared heritage.[41] Many Canadians also benefit from knowing that food production occurs locally, that agricultural land and food security is preserved for future generations and that farming and rural communities remain viable.[42,43,44]

31. Tillage involves plowing or cultivating to prepare land for seeding and bring about favourable conditions for crop growth. Conservation tillage and no-till practices can help improve soil organic matter.
32. Summerfallow involves keeping normally cropped land free of vegetation throughout one growing season using tillage or herbicides, in order to allow a build-up of soil moisture reserves for the next year's crop. Reductions in summerfallow are associated with improvements in soil organic matter.
33. Cover cropping involves planting crops to protect soil from erosion, add organic matter and recycle nutrients and suppress weeds.
34. Green manure is plant material that is grown and incorporated into the soil as a soil improvement practice.
35. McConkey, B.G., D. Cerkowniak, W.N. Smith, R.L. Desjardins and M.J. Bentham, 2010, "Soil Organic Matter," pages 54 to 60 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.
36. A net carbon sink absorbs or takes up more carbon than it releases as part of the carbon cycle.
37. Environment Canada, 2014, *National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada*, *www.ec.gc.ca/ges-ghg/* (accessed May 22, 2014).
38. McConkey, B.G., D. Cerkowniak, W.N. Smith, R.L. Desjardins and M.J. Bentham, 2010, "Soil Organic Matter," pages 54 to 60 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.
39. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), 2014, *Agrotourisme en chiffres*, *www.mapaq.gouv.qc.ca/fr/Productions/agrotourisme/agrotourismechiffres/Pages/agrotourismechiffres.aspx* (accessed March 24, 2014).
40. Frank, Rimerman + Co. and R. Eyler, 2013, *The Economic Impact of the Wine and Grape Industry in Canada 2011*, *www.wgao.ca/uploads/Canada%202011%20Wine%20Industry%20Economic%20Impact%20Report%20FINAL%203-20-13.pdf* (accessed January 30, 2014).
41. United States Environmental Protection Agency, 2002, *Community Culture and the Environment: A Guide to Understanding a Sense of Place*, (EPA 842-B-01-003), Office of Water, Washington, DC., *www.epa.gov/care/library/community_culture.pdf* (accessed May 29, 2014).
42. Food Secure Canada, 2011, *Resetting the Table: A People's Food Policy for Canada*, *http://foodsecurecanada.org/policy-advocacy/resetting-table* (accessed May 6, 2014).
43. Dieticians of Canada, 2010, *Healthy Eating and Food Security: Promising Strategies for BC*, *www.dietitians.ca/Downloadable-Content/Public/Healthy-Eating-and-Food-Security-Strategies-BC.aspx* (May 6, 2014).
44. The Land Conservancy of British Columbia, 2010, *A Review of Farmland Trusts: Communities Supporting Farmland, Farming, and Farmers*, *http://blog.conservancy.bc.ca/wp-content/uploads/2010/12/FLT_dec2010.pdf* (accessed May 12, 2014).

Section 4

Beneficiaries of agricultural ecosystem goods and services

Society is a beneficiary of the final ecosystem goods and services provided by the agricultural environment. Agriculture makes direct and indirect contributions to the Canadian economy. Primary agriculture—crop and animal production—accounted for 1.1% of Canada's gross domestic product (GDP) and 1.6% of employment in 2010. The overall contribution to the economy and society is much larger, however, as agriculture allows for activity in many other important sectors of the economy including food and beverage manufacturing, wholesale, retail and food services. In 2010, the agriculture and agri-food system's[1] GDP accounted for 6.4% of total GDP and 12.1% of total employment.[2,3,4]

Farmers benefit directly from ecosystem services as an input into agricultural production, allowing them to earn a living and maintain their connection to the land and lifestyle. Consumers, whether they are local, regional or global, benefit from Canadian agriculture. Over 70% of the food Canadians bought in 2010 was produced domestically.[5] Canada is particularly self-sufficient for meat, dairy (including eggs), breads and cereals.[6]

People living close to farming communities can also enjoy green space and open vistas provided by agricultural land and enjoy fresh local foods, often sold at local farmers' markets, farm stands, through community-supported agriculture programs and in stores. In 2011, 90% of Canadian households reported that they purchased locally grown or produced foods when they were available or in season.[7] There is a growing interest in local food production, including urban farms, market gardens[8] and backyard gardening (See Textbox 5: Homegrown agriculture for more information).

Textbox 5: Homegrown agriculture

Agriculture doesn't occur just in rural areas—people in cities and towns sometimes grow produce for sale and may even raise chickens or bees in their own backyard. Other people simply enjoy working in their garden, growing fruit, vegetables and flowers for personal use and enjoyment.

More than half of households in Canada (56%) grow fruits, vegetables, herbs or flowers for personal use according to the 2011 Households and the Environment Survey. Two-thirds of households in single-detached dwellings grew these products, compared to 30% of households living in apartments.

These activities are also associated with environmental impacts. Three-quarters of households with an outdoor garden or areas with trees, shrubs, flowers or vegetables, indicated that they watered these areas during 2011. Sprinklers and sprinkler systems were used by 23% of these households, of which 41% were connected to a timer.

Fertilizers and pesticides are also used—55% of households applied chemical or organic products on their lawn or garden in 2011.

Source(s): Statistics Canada, 2013, special tabulation of data from the 2011 Households and the Environment Survey.

1. Includes the following North American Industry Classification System (NAICS) categories: Crop production (111), Animal production (112), Support activities for crop production (1151), Support activities for animal production (1152), Pesticide, fertilizer and other agricultural chemical manufacturing (3253), Food manufacturing (311), Beverage and tobacco product manufacturing (312), Farm product wholesaler-distributors (411), Food, beverage and tobacco wholesaler-distributors (413), Food and beverage stores (445), and Food services and drinking places (722).
2. Statistics Canada, CANSIM table 379-0029 (accessed April 9, 2014).
3. Statistics Canada, Labour Force Survey, 2014, special tabulation.
4. Gross domestic product (GDP) and employment numbers include data for aquaculture.
5. Statistics Canada, Industry Accounts Division, 2014, special tabulation.
6. Ghanem, Z. and P. Cross, 2008, "Food Prices: A boon for producers, a buffer for consumers," *Canadian Economic Observer*, Statistics Canada Catalogue no. 11-010-X, Vol. 21, no. 6.
7. Statistics Canada, 2013, *Households and the Environment, 2011*, Catalogue no. 11-526-X.
8. Steffenhagen, J., 2012, "Vancouver Technical school's market garden to be a Canadian first," *The Vancouver Sun*, June 13, 2012, *www.vancouversun.com/life/Vancouver+Technical+school+market+garden+Canadian+first/6776460/story.html* (accessed August 22, 2014).

4.1 Farmers

Farming communities are changing—farms are getting bigger while the number of farms and farm operators is decreasing and farmers are getting older. These changes influence who benefits directly from agriculture.

Widespread socio-demographic factors have led to consolidation in the farm sector—the number of farms dropped 44% between 1971 and 2011 while the average farm has increased in size from 188 hectares to 315 hectares.[9]

In 2011, the Canadian farm population numbered 650,395 people, 90% of whom lived in rural areas (Table 4.1). Overall, the farm population accounted for 2% of Canadians; however, it represented 10% of the population in rural areas, reaching 28% of the population in rural Saskatchewan and 20% of the population in rural Alberta. The largest farm population was found in Ontario at 174,905 or 27% of the Canadian farm population, followed by Alberta with 129,810 or 20%.

9. Statistics Canada, CANSIM table 004-0002 (accessed March 31, 2014).

Table 4.1
Farm and non-farm population in Canada, 2011

	Farm population [1]		Non-farm population		Total population		Rural farm population as a percentage of rural population	Farm population as a percentage of total population
	Rural	Total	Rural	Total	Rural	Total		
	number						percent	
Canada	**585,180**	**650,395**	**5,566,700**	**32,096,110**	**6,151,880**	**32,746,505**	**9.5**	**2.0**
Newfoundland and Labrador	1,075	1,525	204,520	505,740	205,595	507,265	0.5	0.3
Prince Edward Island	4,940	5,150	69,075	132,225	74,015	137,375	6.7	3.7
Nova Scotia	10,855	11,695	385,285	894,480	396,140	906,175	2.7	1.3
New Brunswick	7,295	7,940	344,545	727,895	351,840	735,835	2.1	1.1
Quebec	90,735	101,675	1,420,790	7,630,845	1,511,525	7,732,520	6.0	1.3
Ontario	163,435	174,905	1,612,235	12,476,885	1,775,670	12,651,790	9.2	1.4
Manitoba	45,660	49,155	271,650	1,125,190	317,310	1,174,345	14.4	4.2
Saskatchewan	91,785	103,885	238,755	904,875	330,540	1,008,760	27.8	10.3
Alberta	119,570	129,810	469,345	3,438,165	588,915	3,567,975	20.3	3.6
British Columbia	49,840	64,650	550,465	4,259,805	600,305	4,324,455	8.3	1.5

1. Farm population refers to all persons who are members of a farm operator's household excluding those residing in Canada's three territories or in collective dwellings.

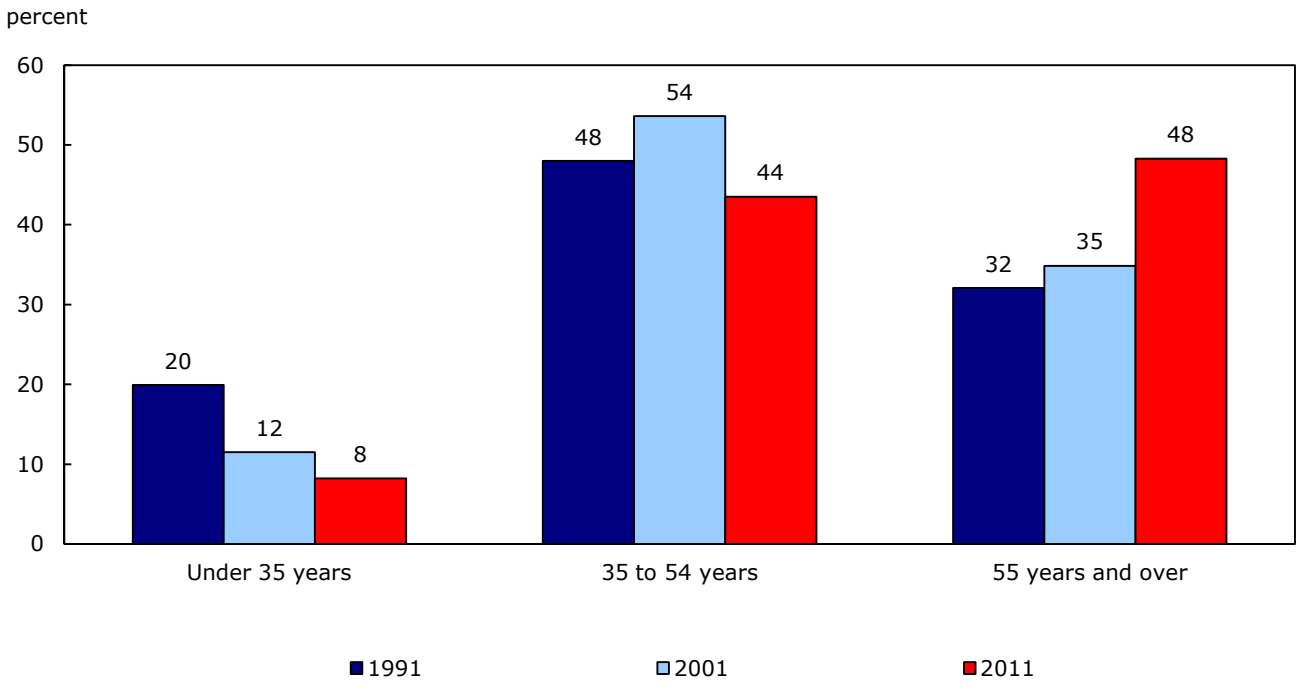
Source(s): Statistics Canada, CANSIM table 004-0126 (accessed May 23, 2014).

From 1991 to 2011, the number of farm operators decreased from 390,875 to 293,925 or 25%, while the average age rose from 48 to 54 years.[10] Close to half (48%) of farm operators were aged 55 and older in 2011, up from one-third (32%) in 1991 (Chart 4.1). Only 8% of operators were under the age of 35 in 2011, down from 20% in 1991. In comparison, 16% of the self-employed labour force was under the age of 35 in 2011.[11]

10. Statistics Canada, CANSIM table 004-0017 (accessed May 27, 2014).

11. Statistics Canada, 2013, *Highlights and analysis: Get to know Canadian farmers and their families*, *www.statcan.gc.ca/ca-ra2011/ha-sa-eng.html* (accessed May 27, 2014).

Chart 4.1
Distribution of farm operators by age, 1991, 2001 and 2011



Source: Statistics Canada, CANSIM table 004-0017 (accessed May 27, 2014).

The high capital costs required to purchase land and machinery, as well as the production quota for dairy and poultry farms can create barriers to entry for young farmers.[12] In 2011, 69% of farms reported total farm capital values of $500,000 and over.[13,14]

The Canadian agricultural sector continues to restructure to fewer, larger farms, resulting in economies of scale allowing improved productivity and sales. While 62% of farms reported having gross farm receipts of less than $100,000 in 2010, their numbers have dropped by 34% since 1990. In contrast, the number of farms earning $500,000 and over, more than doubled (166%) during the same period (in 2010 constant dollars).[15]

In 2010, the median total income for farm families, including farm and off-farm sources, was $74,604 compared to a median total income of $76,458 for all families (Table 4.2).[16] By farm type, poultry and egg producers had the highest median incomes in 2010 at $90,250 while dairy cattle and milk producers had the lowest at $65,010 (Table 4.3).

12. Beaulieu, M.S., 2014, "Demographic Changes in Canadian Agriculture," *Canadian Agriculture at a Glance*, Statistics Canada Catalogue no. 96-325-X.
13. Includes the value of farm machinery and equipment, livestock and poultry, land and buildings.
14. Statistics Canada, 2012, *Farm and Farm Operator Data*, *2011 Census of Agriculture*, Catalogue no. 95-640-X.
15. Statistics Canada, 2012, "Snapshot of Canadian agriculture," *Farm and Farm Operator Data, 2011 Census of Agriculture*, Catalogue no. 95-640-X.
16. Farm family refers to an economic family where at least one person is a farm operator. Economic family refers to a group of two or more persons who live in the same dwelling and are related to each other by blood, marriage, common-law, adoption or a foster relationship.

Table 4.2
Median income for farm economic families and all economic families in Canada, 2010

	Farm economic families	All economic families
	2010 dollars	
Canada	**74,604**	**76,458**
Atlantic provinces	66,625	66,502
Quebec	62,641	68,344
Ontario	80,240	80,987
Manitoba	70,616	72,404
Saskatchewan	75,687	77,448
Alberta	80,928	93,393
British Columbia	77,767	75,797

Note(s): The median total income for farm economic families includes income from farm and off-farm sources. Farm economic family refers to an economic family where at least one person is a farm operator. Economic family refers to a group of two or more persons who live in the same dwelling and are related to each other by blood, marriage, common-law, adoption or a foster relationship.
Source(s): Statistics Canada, 2013, *Highlights and analysis: Get to know Canadian farmers and their families*, *www.statcan.gc.ca/ca-ra2011/ha-sa-eng.html* (accessed February 14, 2014).

Table 4.3
Median income of farm economic families by North American Industry Classification System farm type in Canada, 2010

	Median total income for farm economic families	Percent of farm economic families
	2010 dollars	percent
All types of farming	**74,604**	**100.0**
Poultry and egg production	90,250	2.1
Greenhouse, nursery and floriculture production	82,473	3.9
Oilseed and grain farming	80,865	29.7
Fruit and tree nut farming	80,505	4.1
Other animal production	77,587	11.3
Vegetable and melon farming	76,608	2.6
Other crop farming	71,544	17.3
Hog and pig farming	68,594	1.7
Sheep and goat farming	67,612	1.9
Beef cattle ranching and farming including feedlots	66,873	17.6
Dairy cattle and milk production	65,010	7.9

Note(s): The median total income for farm economic families includes income from farm and off-farm sources. Farm economic family refers to an economic family where at least one person is a farm operator.
Source(s): Statistics Canada, 2013, *Highlights and analysis: Get to know Canadian farmers and their families*, *www.statcan.gc.ca/ca-ra2011/ha-sa-eng.html* (accessed February 14, 2014).

4.2 Consumers

Consumers benefit from the many products generated from agricultural ecosystems. The variety of foods available to Canadian consumers has expanded over the years. Increasing consumer demand for things like healthier food choices, local foods and organic products have influenced the foods available in both stores and restaurants.

While the amount Canadians are spending on food is increasing, the proportion it makes up of their total personal spending is decreasing. In 1981, Canadians dedicated 12% of their total personal spending to food and non-alcoholic beverages. In 2011, this amount had decreased to 8%.[17]

Not all agricultural products enter the food system. Agricultural biomass is also used to make industrial bioproducts—products made from renewable biological inputs. In 2009, Canadian bioproduct firms[18] obtained

17. Statistics Canada, CANSIM table 380-0024 (accessed April 8, 2014).
18. This survey focuses on non-conventional industrial bioproducts. Examples include biofuels (e.g., ethanol and biodiesel), organic chemicals (e.g., biopolymers), pesticides, non-conventional building/construction materials and composites. Traditional bioproducts, such as wood products, would be considered in-scope for this survey only if they were made by a non-conventional or novel process.

their biomass from farms over any other source. Agricultural biomass accounted for 11 million tonnes of the more than 27 million tonnes of biomass used by these firms in 2009.[19]

Once agricultural products have been produced and harvested they are shipped both domestically and globally. In 2013, international exports of farm, fishing and intermediate food products reached $27.9 billion—6% of all merchandise exports—with wheat (24%), food and tobacco intermediate products (21%), other crop products (18%) and canola (15%) accounting for the largest proportions (Table 4.4).

19. Rothwell, N., B. Khamphoune and C. Neumeyer, 2011, "Results from Statistics Canada's Bioproducts Production and Development Survey 2009," *Business Special Surveys and Technology Statistics Division Working Papers*, Statistics Canada Catalogue no. 88F0006X, no. 1.

Table 4.4
Exports of farm, fishing and intermediate food products

	Live animals	Wheat	Canola	Fruits, nuts and vegetables	Other crop products [1]	Other animal products [2]	Fish, shellfish and other fishery products	Food and tobacco intermediate products	Total, farm, fishing and intermediate food products	Total as a share of Canadian exports
	millions of current dollars									percent
1991	900.0	3,131.7	543.0	287.7	1,105.7	138.3	514.3	667.4	7,288.0	4.9
1992	1,272.3	3,746.2	566.0	287.5	1,091.5	137.4	559.6	860.5	8,520.8	5.2
1993	1,378.6	2,886.7	724.8	333.1	1,288.9	145.8	625.9	995.7	8,380.1	4.4
1994	1,318.1	3,472.6	1,552.9	428.9	1,649.5	159.9	751.2	1,201.6	10,534.6	4.6
1995	1,496.7	4,234.2	1,246.9	472.0	1,882.5	166.3	811.1	1,301.6	11,611.2	4.4
1996	1,866.9	4,560.9	1,145.0	533.6	2,288.5	218.9	818.3	1,754.9	13,187.3	4.7
1997	1,882.6	4,983.1	1,111.3	563.5	2,284.0	226.6	897.2	1,907.6	13,855.9	4.6
1998	1,948.5	3,568.1	1,618.4	791.4	1,950.8	219.8	971.8	2,187.7	13,256.8	4.1
1999	1,537.0	3,316.9	1,316.3	863.7	1,673.8	213.3	1,083.3	1,744.8	11,749.0	3.2
2000	1,706.9	3,566.3	1,133.0	932.2	1,676.5	252.8	1,142.0	1,684.5	12,093.8	2.8
2001	2,352.9	3,761.8	1,259.2	1,086.4	1,763.5	263.2	1,262.4	1,670.5	13,420.0	3.2
2002	2,463.0	3,014.2	907.6	1,232.8	1,787.6	279.2	1,355.0	1,647.3	12,686.9	3.1
2003	1,287.1	2,769.5	1,277.7	1,221.1	1,744.3	299.2	1,257.5	1,842.4	11,698.8	2.9
2004	840.8	3,450.0	1,392.8	1,262.7	1,892.5	325.8	1,176.3	2,339.7	12,681.3	3.0
2005	1,511.9	2,665.9	1,278.6	1,303.5	1,949.4	363.2	1,220.8	1,942.2	12,236.0	2.7
2006	1,985.9	3,589.1	1,727.0	1,370.2	2,103.4	469.0	1,255.9	2,092.0	14,592.3	3.2
2007	2,401.2	4,611.1	2,248.3	1,361.4	2,967.3	427.2	1,230.4	2,631.9	17,878.9	3.9
2008	2,299.7	6,830.8	3,827.5	1,473.2	3,929.8	478.4	1,176.1	3,938.6	23,953.7	4.9
2009	1,617.2	5,770.0	3,426.1	1,423.5	3,181.2	402.2	1,170.5	3,340.6	20,330.7	5.5
2010	1,662.3	4,387.9	3,348.5	1,492.7	3,487.0	545.9	1,196.0	4,024.8	20,144.6	5.0
2011	1,410.4	5,651.5	4,529.9	1,580.0	3,728.3	620.1	1,210.2	5,406.3	24,136.3	5.3
2012	1,608.6	6,103.0	5,128.1	1,572.8	4,650.5	802.6	1,270.8	6,097.0	27,233.6	5.9
2013	1,877.5	6,721.6	4,256.5	1,889.1	4,901.4	1,078.8	1,332.6	5,793.9	27,850.8	5.8

1. Includes grains (except wheat), oilseeds (except canola), and other crop products, not elsewhere classified.
2. Includes eggs in a shell, unprocessed fluid milk, and raw furskins; animal products not elsewhere classified.

Note(s): Merchandise exports on a balance of payments basis. Figures may not add up to totals due to rounding.
Source(s): Statistics Canada, CANSIM table 228-0059 (accessed May 28, 2014).

Section 5

Environmental management

A variety of practices have been adopted by farmers to manage the impacts of agricultural activities on the environment. Restoration activities, such as converting marginal cropland to pasture, planting riparian buffers, and protecting and restoring wetland functions, help maintain or improve the capability of the land to produce valuable ecosystem goods and services.

5.1 Impacts

Many agricultural activities can have environmental impacts on land, water, and air. These environmental impacts will differ based on the farm location, farm type, and the specific farming and land management practices used as well as the timing of these practices (i.e., season of fertilizer application). For example, nutrients and pesticides can run off agricultural fields into surface water bodies or leach into groundwater. Increased phosphorus loading from agriculture is one of several factors that have resulted in algal blooms in both Lake Erie and Lake Winnipeg.[1,2,3]

5.1.1 Nutrients and pesticides

A number of nutrients are essential for plant growth, in particular nitrogen, phosphorus and potassium. Commercial fertilizers and livestock manure are often used to supplement the nutrients in the soil to the levels required by crops for maximum productivity and economic returns. Applying manure also adds needed organic matter to soil, helping to improve soil structure.[4]

Care must be taken, however, to apply these nutrients correctly to minimize impacts on water. If applied in excess, nitrogen and phosphorus in fertilizer and manure can run off into surface water bodies or groundwater, causing excessive growth of aquatic plants, such as algae, and the subsequent depletion of dissolved oxygen as the plants breakdown after they die. This oxygen depletion can change the composition of the aquatic community and, in extreme cases cause the death of fish and other organisms.[5] The safety of the drinking water supply, including the potential impacts on human health of nitrogen in drinking water, is also of concern to Canadians.[6] Several provinces have strict legislation with regards to nutrient management and manure handling.

Pesticides are applied to agricultural crops to prevent losses from weeds, insects, fungi and parasites. While pesticides can help maintain crop yields and quality, they also have the potential to contaminate surface water and groundwater. This contamination can affect ecosystems, including impacts on individual species and biodiversity and can potentially result in human health impacts.[7]

In 2011, 69% of Canadian crop farms applied commercial fertilizers (Table 5.1). There was little variability in fertilizer application across the country—it was most commonly reported in Ontario and Manitoba (75%) and least commonly reported in British Columbia (63%).

1. Michalak, A.M., E.J. Anderson, D. Beletsky, S. Boland, N.S. Bosch, T.B. Bridgeman, J.D. Chaffin, K. Cho, R. Confessor, I. Daloglu, J.V. DePinto, M.A. Evans, G.L. Fahnenstiel, L. He, J.C. Ho, L. Jenkins, T.H. Johengen, K.C. Kuo, E. LaPorte, X. Liu, J.R. McWilliams, M.R. Moore, D.J. Posselt, R.P. Richards, D. Scavia, A.L. Steiner, E. Verhamme, D.M. Wright and M.A. Zagorski, 2013, "Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions," *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 10, no. 16, pages 6448 to 6452.
2. Schindler, D.W., R.E. Hecky and G.K. McCullough, 2012, "The rapid eutrophication of Lake Winnipeg: Greening under global change," *Journal of Great Lakes Research*, Vol. 38, Supplement 3, pages 6 to 13.
3. Environment Canada, 2013, *Land Use Impacts on Freshwater Quality*, *http://ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=88872F95-1* (accessed February 3, 2014).
4. Dorff, E. and M.S. Beaulieu, 2014, "Feeding the soil puts food on your plate," *Canadian Agriculture at a Glance,* Statistics Canada Catalogue no. 96-325-X.
5. MacKay, R. and J. Hewitt, 2010, "Farm Environmental Management," pages 20 to 30 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.
6. De Jong, R., C.F. Drury and J.Y. Yang, 2010, "Water Contamination by Nitrogen," pages 80 to 86 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.
7. Ongley, E.D., 1996, *Control of water pollution from agriculture*, FAO Irrigation and Drainage Paper No. 55, Food and Agriculture Organization of the United Nations, *www.fao.org/docrep/w2598e/w2598e00.HTM* (accessed May 29, 2014).

In 2011, 69% of Canadian crop farms reported applying herbicides, 15% reported applying insecticides and 23% reported applying fungicides (Table 5.1). Herbicide application was most commonly reported by crop farms in Saskatchewan (79%) and Manitoba (77%) while insecticide application was most common in the Atlantic provinces (34%) and British Columbia (28%). Fungicide application was most commonly reported by farmers in Manitoba (42%) and least commonly by farmers in Quebec (10%).

Table 5.1
Proportion of crop farms using commercial fertilizers and pesticides, by province or region, 2011

	Commercial fertilizers or micronutrients applied	Application of herbicides	Application of insecticides	Application of fungicides
	percent			
Canada	**69**	**69**	**15**	**23**
Atlantic provinces	65	57	34	34
Quebec	66	62	11	10
Ontario	75	70	16	25
Manitoba	75	77	15	42
Saskatchewan	69	79	14	24
Alberta	65	65	11	15
British Columbia	63	40	28	29

Source(s): Statistics Canada, 2013, Farm Environmental Management Survey, special tabulation. Statistics Canada, 2013, *Farm Environmental Management Survey, 2011*, Catalogue no. 21-023-X.

From 2001 to 2011 there was a 4% increase in fertilized land area in Canada (Table 5.2). In 2011, the largest fertilized areas were found in drainage regions in the Prairies: Assiniboine–Red (7,496,870 hectares), South Saskatchewan (5,195,829 hectares) and North Saskatchewan (4,499,229 hectares). As a percentage of cropland area, the North Saskatchewan (76%), Assiniboine–Red (75%) and South Saskatchewan (75%) drainage regions also had the highest percentages of fertilized land.

Table 5.2
Area fertilized by drainage region, 2001 and 2011

	Total farm area		Cropland area		Area fertilized		
	2001	2011	2001	2011	2001	2011	Percentage change 2001 to 2011
	hectares						percent
Canada	**67,502,447**	**64,812,723**	**36,395,151**	**35,350,270**	**24,014,814**	**24,917,875**	**3.8**
Pacific Coastal	162,048	145,972	41,798	36,573	24,540	18,269	-25.6
Fraser–Lower Mainland	1,199,185	1,303,629	229,782	236,282	141,922	122,412	-13.7
Okanagan–Similkameen	147,477	159,460	32,972	27,082	19,161	15,011	-21.7
Columbia	184,274	159,418	35,592	27,603	18,596	14,773	-20.6
Peace–Athabasca	4,981,336	4,713,779	2,436,347	2,342,098	1,428,712	1,506,473	5.4
Lower Mackenzie	0	14,471	0	2,300	0	247	…
Missouri	2,436,331	2,300,651	690,542	714,796	304,308	393,104	29.2
North Saskatchewan	10,987,401	10,524,579	6,011,302	5,927,264	4,163,505	4,499,229	8.1
South Saskatchewan	14,646,886	14,370,278	6,661,777	6,936,846	4,662,240	5,195,829	11.4
Assiniboine–Red	16,477,083	15,603,620	10,862,438	10,004,061	7,451,054	7,496,870	0.6
Winnipeg	155,901	149,910	65,792	63,303	41,146	31,598	-23.2
Lower Saskatchewan–Nelson	4,906,631	4,725,146	2,917,219	2,721,455	2,045,646	1,875,168	-8.3
Churchill	1,249,546	1,182,304	460,862	410,459	192,325	184,361	-4.1
Northern Ontario	90,590	91,489	37,733	37,517	12,706	8,756	-31.1
Northern Quebec	47,622	46,268	17,615	18,048	3,745	2,132	-43.1
Great Lakes	4,437,540	4,183,468	3,120,360	3,075,924	1,947,255	2,063,060	5.9
Ottawa	1,180,158	1,091,804	595,359	599,804	286,639	296,348	3.4
St. Lawrence	2,461,313	2,391,958	1,454,505	1,446,947	870,631	845,122	-2.9
North Shore–Gaspé	380,782	396,161	204,907	222,647	73,201	70,011	-4.4
Saint John–St. Croix	366,601	357,045	129,953	120,020	72,816	60,958	-16.3
Maritime Coastal	848,888	849,161	381,789	356,538	234,666	200,713	-14.5
Newfoundland–Labrador	36,907	30,951	8,071	7,862	5,829	5,112	-12.3

Note(s): The data for land management practices are reported for the year preceding the census year. Any differences between the results by drainage region and national totals are due to data suppression to protect confidentiality. See Statistics Canada, 2008, *Census of Agriculture: Environmental Geography Aggregations of Census Farm Units* (survey number 8012) for further details. Drainage regions are part of Statistics Canada's standard drainage area classification. See Statistics Canada, Standards Division, 2009, *Standard Drainage Area Classification (SDAC) 2003*, *www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdac-ctad-eng.htm* for further details.

Source(s): Statistics Canada, CANSIM tables 004-0002 and 004-0010 (accessed February 3, 2014). Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2001 and 2011.

From 2001 to 2011 there was a 3% increase in the area of farmland treated with herbicides, a 42% increase in the area of farmland treated with insecticides and a 114% increase in the area of farmland treated with fungicides (Table 5.3). The greatest areas of farmland treated with herbicides and fungicides in 2011 were in the Assiniboine–Red , South Saskatchewan and North Saskatchewan drainage regions, which are also the three drainage regions with the greatest areas of both farmland and cropland. The greatest areas of farmland treated with insecticides were in the Assiniboine–Red , South Saskatchewan and Great Lakes drainage regions. Several factors can influence the use of pesticides. For example, in the United States, the use of conservation tillage practices as well as the adoption of crops genetically engineered to tolerate herbicides have both been found to increase herbicide use.[8,9]

Looking at application areas as a percentage of cropland reveals different patterns for the application of insecticide and fungicide. Drainage regions with the highest percentage of cropland area treated with insecticide in 2011 were the Okanagan–Similkameen (28.3%), Saint John–St. Croix (19.0%) and Maritime Coastal (15.7%). Drainage regions with the highest percentage of cropland area treated with fungicide in 2011 were the Okanagan–Similkameen (28.0%), Assiniboine–Red (24.5%) and Saint John–St. Croix (20.8%).

8. Muir, P., 2012, *Pesticide Use in the US*, *http://people.oregonstate.edu/~muirp/uspestic.htm* (accessed May 12, 2014).
9. Benbrook, C.M., 2012, "Impacts of genetically engineered crops on pesticide use in the U.S. - the first sixteen years," *Environmental Sciences Europe*, Vol. 24, *www.enveurope.com/content/24/1/24* (accessed May 12, 2014).

Table 5.3
Area treated with herbicide, insecticide and fungicide, by drainage region, 2001 and 2011

	Area treated with herbicide			Area treated with insecticide			Area treated with fungicide		
	2001	2011	Percentage change 2001 to 2011	2001	2011	Percentage change 2001 to 2011	2001	2011	Percentage change 2001 to 2011
	hectares		percent	hectares		percent	hectares		percent
Canada	**25,900,911**	**26,699,392**	**3.1**	**2,225,938**	**3,149,803**	**41.5**	**2,572,388**	**5,510,681**	**114.2**
Pacific Coastal	3,930.0	3,473.6	-11.6	1,181.3	654.3	-44.6	1,053.4	756.4	-28.2
Fraser–Lower Mainland	33,302.7	43,914.4	31.9	13,197.5	17,239.8	30.6	11,110.4	14,433.2	29.9
Okanagan–Similkameen	11,891.5	10,137.1	-14.8	8,348.7	7,653.7	-8.3	8,603.9	7,579.9	-11.9
Columbia	4,584.4	5,602.2	22.2	775.5	928.5	19.7	812.9	741.9	-8.7
Peace–Athabasca	1,265,049.5	1,440,455.2	13.9	94,047.8	250,605.8	166.5	70,701.9	128,511.3	81.8
Missouri	470,458.1	511,391.7	8.7	14,531.0	27,241.9	87.5	29,035.5	38,568.3	32.8
North Saskatchewan	4,504,377.5	4,698,078.7	4.3	222,747.8	334,664.3	50.2	298,582.8	679,740.3	127.7
South Saskatchewan	5,385,077.4	5,665,668.1	5.2	337,357.3	628,642.7	86.3	477,694.5	1,042,451.7	118.2
Assiniboine–Red	8,674,190.4	8,516,465.0	-1.8	777,934.7	953,417.8	22.6	1,057,787.5	2,447,455.0	131.4
Winnipeg	26,205.2	24,043.3	-8.2	6,465.7	1,713.2	-73.5	2,837.4	2,724.8	-4.0
Lower Saskatchewan–Nelson	2,100,696.5	2,050,984.4	-2.4	198,405.8	258,725.8	30.4	248,243.3	548,928.6	121.1
Churchill	179,756.5	173,599.0	-3.4	5,370.6	12,911.9	140.4	7,940.2	25,773.9	224.6
Northern Ontario	2,564.6	3,057.2	19.2	0.0	0.0	…	40.1	0.0	-100.0
Northern Quebec	438.9	914.4	108.4	52.2	0.0	-100.0	30.7	0.0	-100.0
Great Lakes	1,986,977.4	2,115,517.4	6.5	336,935.3	440,778.2	30.8	182,646.5	369,057.3	102.1
Ottawa	224,948.8	290,720.9	29.2	22,986.0	32,661.8	42.1	10,400.0	27,866.6	167.9
St. Lawrence	770,381.2	858,338.1	11.4	85,278.0	89,031.9	4.4	68,927.7	74,202.3	7.7
North Shore–Gaspé	56,116.5	72,203.5	28.7	4,623.1	5,878.3	27.1	3,935.2	6,284.6	59.7
Saint John–St. Croix	48,022.5	51,393.9	7.0	25,983.1	22,792.8	-12.3	24,035.6	24,957.5	3.8
Maritime Coastal	139,511.2	150,155.0	7.6	64,674.6	55,833.7	-13.7	58,641.3	60,695.8	3.5
Newfoundland–Labrador	1,030.8	1,382.3	34.1	614.4	372.7	-39.3	296.2	167.6	-43.4

Note(s): The data for land management practices are reported for the year preceding the census year. Any differences between the results by drainage region and national totals are due to data suppression to protect confidentiality. See Statistics Canada, 2008, *Census of Agriculture: Environmental Geography Aggregations of Census Farm Units* (survey number 8012) for further details. Drainage regions are part of Statistics Canada's standard drainage area classification. See Statistics Canada, Standards Division, 2009, *Standard Drainage Area Classification (SDAC) 2003*, *www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdac-ctad-eng.htm* for further details.

Source(s): Statistics Canada, CANSIM table 004-0010 (accessed February 3, 2014). Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2001 and 2011.

In 2011, livestock on Canadian farms produced almost 152 million tonnes of manure (Table 5.4). Cattle accounted for 84% of this production, pigs 8% and poultry 3%.[10] Over 50% of total manure production occurred in the South Saskatchewan and Assiniboine–Red drainage regions located in the Prairies and the Great Lakes drainage region in southern Ontario. These three drainage regions had among the highest inventories of cattle, poultry and hogs in the country.

This manure contained almost 1 million tonnes of nitrogen, over 255,000 tonnes of phosphorus and over 542,000 tonnes of potassium. The Newfoundland–Labrador, St. Lawrence and Great Lakes drainage regions had the highest nutrient production from manure per farm area.

10. Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011.

Table 5.4
Livestock manure production and selected nutrients, by drainage region, 2011

	Manure		Nitrogen		Phosphorus		Potassium	
	tonnes	kilograms per hectare of farm area	tonnes	kilograms per hectare of farm area	tonnes	kilograms per hectare of farm area	tonnes	kilograms per hectare of farm area
Total	**151,610,046**		**925,166**		**255,111**		**542,673**	
Pacific Coastal	596,561	4,086.8	3,750	25.7	969	6.6	2,152	14.7
Fraser–Lower Mainland	5,361,732	4,112.9	35,138	27.0	9,413	7.2	19,224	14.7
Okanagan–Similkameen	445,483	2,793.7	2,740	17.2	725	4.5	1,647	10.3
Columbia	369,728	2,319.2	2,168	13.6	571	3.6	1,355	8.5
Peace–Athabasca	7,644,748	1,621.8	45,168	9.6	12,215	2.6	28,074	6.0
Lower Mackenzie	14,219	982.6	84	5.8	22	1.5	55	3.8
Missouri	2,706,557	1,176.4	15,962	6.9	4,353	1.9	9,847	4.3
North Saskatchewan	18,800,182	1,786.3	111,956	10.6	30,436	2.9	68,453	6.5
South Saskatchewan	33,685,747	2,344.1	200,122	13.9	54,549	3.8	122,257	8.5
Assiniboine–Red	22,291,806	1,428.6	134,874	8.6	38,464	2.5	80,974	5.2
Winnipeg	407,040	2,715.2	2,464	16.4	682	4.5	1,453	9.7
Lower Saskatchewan–Nelson	6,949,515	1,470.8	41,526	8.8	11,588	2.5	25,375	5.4
Churchill	2,478,209	2,096.1	14,581	12.3	3,958	3.3	9,060	7.7
Northern Ontario	349,119	3,816.0	2,040	22.3	539	5.9	1,243	13.6
Northern Quebec	143,637	3,104.5	877	19.0	236	5.1	504	10.9
Great Lakes	21,503,422	5,140.1	138,757	33.2	38,923	9.3	76,908	18.4
Ottawa	4,709,084	4,313.1	27,714	25.4	7,060	6.5	15,802	14.5
St. Lawrence	17,426,442	7,285.4	109,520	45.8	31,119	13.0	58,676	24.5
North Shore–Gaspé	1,763,512	4,451.5	10,403	26.3	2,639	6.7	5,844	14.8
Saint John–St. Croix	946,327	2,650.4	6,106	17.1	1,639	4.6	3,261	9.1
Maritime Coastal	2,797,076	3,293.9	17,600	20.7	4,589	5.4	9,745	11.5
Newfoundland–Labrador	219,899	7,104.8	1,615	52.2	422	13.6	763	24.6

Note(s): Drainage regions are part of Statistics Canada's standard drainage area classification. See Statistics Canada, Standards Division, 2009, *Standard Drainage Area Classification (SDAC) 2003*, *www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdac-ctad-eng.htm* for further details.
Source(s): Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011.

5.1.2 Water use

Water is essential for crop and livestock production. In Canada, most crops are rain-fed but some are dependent on irrigation; during periods of little rain, irrigation is used to augment soil moisture, ensuring higher and more predictable crop yields. In 2005, irrigation accounted for only 1.8% of the total quantity of water that contributed to crop growth.[11]

In 2011, agriculture used 1.8 billion m^3 of water, 85% for crop production and 15% for animal production. Overall, the sector was responsible for 5% of the 35.4 billion m^3 of water withdrawn from Canada's rivers, lakes and groundwater by household and economic activities in 2011.[12] However, unlike thermal power generation and other major water users that discharge most water withdrawals back into the environment; agriculture consumes[13] most of the water withdrawn for use. Agriculture consumed approximately 84%[14] or 1.5 billion m^3 of the water withdrawn for crop and animal production in 2011.

According to the Agricultural Water Survey, almost 1.7 billion m^3 of water were used for irrigation in 2012. Almost 40% of this water was applied in July and 24% was applied in August,[15] when water availability is at a low and the pressure on water resources is peaking from competing demands.[16] The South Saskatchewan, the majority of which is in Alberta, accounted for 77% of the total volume of water used for irrigation. Drainage regions in British Columbia—Pacific Coastal, Fraser–Lower Mainland, Okanagan–Similkameen and Columbia—were responsible for 14% (Table 5.5).

11. Statistics Canada, 2010, "Freshwater supply and demand in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X
12. Statistics Canada, CANSIM table 153-0116 (accessed July 9, 2014).
13. Water consumption is calculated as the difference between water intake and water discharge and is the portion of water not returned directly to the water environment. Please see Appendix A in Statistics Canada, "Freshwater supply and demand in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X.
14. Environment Canada, 2013, *Water Withdrawal and Consumption by Sector*, *http://ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=5736C951-1* (accessed February 3, 2014).
15. Statistics Canada, 2013, *Agricultural Water Use in Canada, 2012*, Catalogue no. 16-402-X.
16. Statistics Canada, 2010, "Freshwater supply and demand in Canada," *Human Activity and the Environment*, Catalogue no. 16-201-X.

17. Statistics Canada, 2013, *Agricultural Water Use in Canada, 2012*, Catalogue no. 16-402-X.

The irrigation intensities for irrigated field crops (2,998 cubic metres/hectare) and forage crops (2,894 cubic metres/hectare) were higher than those for fruit crops (2,093 cubic metres/hectare) and vegetable crops (1,328 cubic metres/hectare) (Table 5.5). Field crops and forage crops made up 99% of the land that received irrigation in the South Saskatchewan—the drainage region that received the most irrigation in terms of volume and area in 2012.[17]

Table 5.5
Total irrigation volume and irrigation volume per hectare by crop type, by drainage region, 2012

	Total volume	Irrigation intensities				
		Field crops [1]	Fruit	Vegetable	Forage crops [2]	All crops
	thousands of cubic metres	cubic metres per hectare				
Canada [3]	**1,692,331**	**2,998**	**2,093**	**1,328**	**2,894**	**2,863**
Pacific Coastal	9,991	1,904	F	3,429	1,784	2,011
Fraser–Lower Mainland	148,806	1,229	786 E	F	3,930	3,149
Okanagan–Similkameen	47,349	x	3,413	x	5,963	4,373
Columbia	28,685 E	x	1,033	x	4,957 E	4,810 E
Missouri	22,586	2,131	…	…	1,942	1,988
North Saskatchewan	x	2,304	x	x	1,783	x
South Saskatchewan	1,295,392	3,181	…	1,147 E	2,579	2,969
Assiniboine–Red	27,568	1,795	1,008 E	F	2,198	1,787
Winnipeg, Lower Saskatchewan–Nelson and Churchill	44,645	3,808	x	x	x	3,779
Great Lakes	36,896	x	1,352	1,596	x	1,312
Ottawa	x	x	1,824 E	x	x	x
St. Lawrence	17,826	1,637	2,174 E	1,030	381	1,493
North Shore–Gaspé, Saint John–St. Croix, Maritime Coastal and Newfoundland–Labrador	5,650	852 E	3,464 E	x	x	1,558 E

1. Includes annual field crops and tame forages, including barley and potatoes.
2. Includes any cultivated grass or legume crop which has been (or will be) cut and dried principally for hay or ensilage.
3. Excludes Yukon, Peace–Athabasca, Lower Mackenzie, Arctic Coast–Islands, Keewatin–Southern Baffin Island, Northern Ontario and Northern Quebec.

Note(s): Includes farms which reported sales of $10,000 on the 2011 Census of Agriculture. Figures may not add up to totals due to rounding.
Source(s): Statistics Canada, 2013, *Agricultural Water Use in Canada, 2012*, Catalogue no. 16-402-X.

5.1.3 Criteria air contaminants

Criteria air contaminants (CACs) are a group of pollutants that can cause smog, acid rain and other environmental and health issues. Agriculture is an important source of two CACs—ammonia (NH_3) and particulate matter (PM).

Agriculture is the main source of atmospheric emissions of NH_3, which is produced from livestock and poultry manure management and fertilizer application. When agricultural emissions of NH_3 occur near population centres they can interact with sulphates and nitrates from industry to form secondary fine particulate matter ($PM_{2.5}$), which can have harmful effects on both human health and the environment. Secondary $PM_{2.5}$ related to agricultural NH_3 emissions has been reported in southern Ontario and the Lower Fraser Valley in British Columbia.[18] From 1985 to 2011, emissions of NH_3 from agriculture increased 29% from 354,480 tonnes to 458,051 tonnes. In 2011, agriculture was responsible for 88% of total emissions of NH_3.[19]

Dust from soil and biological material, droplets and particles from agrochemicals and bacteria affecting both indoor and outdoor air quality are the main

18. Sheppard, S., and S. Bittman, 2010, "Ammonia," pages 118 to 125 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.

19. Environment Canada, 2013, *National Emission Trends for Key Air Pollutants, 1985-2011*, *www.ec.gc.ca/inrp-npri/default.asp?lang=en&n=0EC58C98-#sommaires* (accessed February 3, 2014).

agricultural sources of particulate matter (PM).[20] PM decreases visibility, contributes to stratospheric ozone depletion, acid rain and smog, and influences climate by altering the amount of incoming solar energy and the amount of outgoing terrestrial energy radiating back into space. PM has been linked to a number of cardiac and respiratory diseases as well as various forms of heart disease. It also can have harmful effects on vegetation.[21,22]

From 1985 to 2011, emissions of total particulate matter (TPM) from agriculture decreased 14% from 1,832,225 tonnes to 1,581,049 tonnes. In 2011, agriculture was responsible for 8% of total emissions of TPM, down from 14% in 1985. Agriculture was the fourth largest source of TPM in 2011, following dust from unpaved roads (49%), construction operations (19%) and dust from paved roads (19%).[23]

20. Pattey, E., G. Qui and R. van Haarlem, 2010, "Particulate Matter," pages 126 to 131 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.
21. Pattey, E., G. Qui and R. van Haarlem, 2010.
22. Environment Canada, 2013, *Particulate Matter*, *www.ec.gc.ca/air/default.asp?lang=En&n=2C68B45C-1* (accessed February 12, 2014).
23. Environment Canada, 2013, *National Emission Trends for Key Air Pollutants, 1985-2011*, *www.ec.gc.ca/inrp-npri/default.asp?lang=en&n=0EC58C98-#sommaires* (accessed February 3, 2014).
24. Environment Canada, 2014, *National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada*, *www.ec.gc.ca/ges-ghg/* (accessed May 22, 2014).
25. Environment Canada, 2014.
26. A net carbon sink absorbs or takes up more carbon than it releases as part of the carbon cycle.
27. Desjardins, R.L., D.E. Worth, X.P.C. Vergé, B.G. McConkey, J.A. Dyer and D. Cerkowniak, 2010, "Agricultural Greenhouse Gases," pages 110 to 117 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.

5.1.4 Greenhouse gas emissions and removals

In 2012, agriculture generated 56 megatonnes of carbon dioxide equivalent greenhouse gas emissions (Mt CO_2 eq GHG), 8% of Canada's total (Table 5.6). GHG emissions from agriculture increased 19% (9 Mt CO_2 eq) from 1990 to 2012. A further 14 Mt CO_2 eq were attributed to on-farm energy use in 2012, up from 8 Mt CO_2 eq in 1990, a 75% increase.[24]

These increases were due to higher populations of beef cattle and pigs, as well as an increase in the use of synthetic nitrogen fertilizers.[25]

The widespread adoption no-till practices and the steady decline in the area of summerfallow land have resulted in cropland turning from a net source of GHG emissions to a net sink.[26,27] In 1990 cropland was a source of 12 Mt CO_2 eq GHG to the atmosphere while in 2012 net removals of GHGs by cropland was 5 Mt CO_2 eq.[28]

The intensity of GHG emissions compares GHG emissions to the value of agricultural output; crop and animal production emitted 2.38 tonnes of CO_2 equivalent emissions per thousand current dollars of production in 2010.[29] Over time, intensity measures can indicate whether the industry is becoming more efficient.

28. Environment Canada, 2014, *National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada*, *www.ec.gc.ca/ges-ghg/* (accessed May 22, 2014).
29. Statistics Canada, CANSIM table 153-0115 (accessed July 3, 2014).

Table 5.6
Greenhouse gas emissions from agriculture in Canada, selected years, 1990 to 2012

	1990	2000	2005	2010	2012	Percentage change 1990 to 2012
	kilotonnes of carbon dioxide equivalent					percent
Total [1]	**591,000**	**721,000**	**736,000**	**699,000**	**699,000**	**18.3**
Agriculture	47,000	56,000	58,000	55,000	56,000	19.1
Enteric fermentation	16,000	20,000	22,000	18,000	18,000	12.5
Manure management	5,700	7,000	7,500	6,500	6,400	12.3
Agriculture soils	25,000	29,000	29,000	30,000	32,000	28.0
Direct sources	14,000	15,000	15,000	17,000	17,000	21.4
Pasture, range and paddock manure	2,200	3,100	3,400	2,800	2,700	22.7
Indirect sources	8,700	10,000	10,000	11,000	12,000	37.9
Field burning of agricultural residues	210	120	40	30	30	-85.7

1. National totals exclude all greenhouse gases from the land use, land-use change and forestry sector.
Note(s): Classification according to United Nations Framework Convention on Climate Change. Figures may not add up to totals due to rounding. Agriculture emissions related to burning of fossil fuels for energy—including driving tractors, heating and drying grain—are reported under energy production and use.
Source(s): Environment Canada, 2014, *National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada*, *www.ec.gc.ca/ges-ghg/* (accessed May 22, 2014).

5.2 Management

Environmental farm plan (EFP) programs, which help farmers assess the environmental issues or concerns on farms, began in Ontario in 1993 and now operate in all provinces.[30] Although participation is voluntary, 35% of Canadian farms had a formal EFP in 2011. In Quebec (72%) and the Atlantic provinces (53%), the number of farms with an EFP was greater than the number without (Table 5.7). Some differences in participation may be due to differences in the provincial programs, as well as with differences in provincial legislation targeting nutrient and manure management.[31]

An EFP also includes an action plan detailing the beneficial management practices (BMP) that should be put in place to improve environmental conditions.[32] BMPs are farming methods designed to minimize potential negative impacts on the environment. Farmers across Canada have implemented a number of BMPs to manage manure, fertilizers and pesticides and protect land and water resources.[33] In 2011, 43% of Canadian farms with an EFP had fully implemented their plan's BMPs while 52% had partially implemented them (Table 5.7). Quebec had the highest proportion of farms with fully implemented BMPs (76%).

30. Ontario Ministry of Agriculture and Food, 2013, *Canada-Ontario Environmental Farm Plan*, *www.omafra.gov.on.ca/english/environment/efp/efp.htm* (accessed May 8, 2014).
31. MacKay, R. and J. Hewitt, 2010, "Farm Environmental Management," pages 20 to 30 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.
32. Ontario Ministry of Agriculture and Food, 2013, *Canada-Ontario Environmental Farm Plan*, *www.omafra.gov.on.ca/english/environment/efp/efp.htm* (accessed February 14, 2014).
33. MacKay, R. and J. Hewitt, 2010, "Farm Environmental Management," pages 20 to 30 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.

Table 5.7
Environmental farm plans and beneficial management practices on Canadian farms, by province or region, 2011

	Environmental farm plan			Beneficial management practices [1]		
	No	Under development /review	Yes	Fully implemented	Partially implemented	Not implemented
	percent					
Canada	**60**	**2**	**35**	**43**	**52**	**5**
Atlantic provinces	42	2	53	41	53	4
Quebec	23	3	72	76	22	2
Ontario	58	1 [E]	38	38	56	6
Manitoba	66	4	28	25	68	7
Saskatchewan	69	2	26	18	76	6
Alberta	73	1	23	20	73	6
British Columbia	72	3	21	58	36	4 [E]

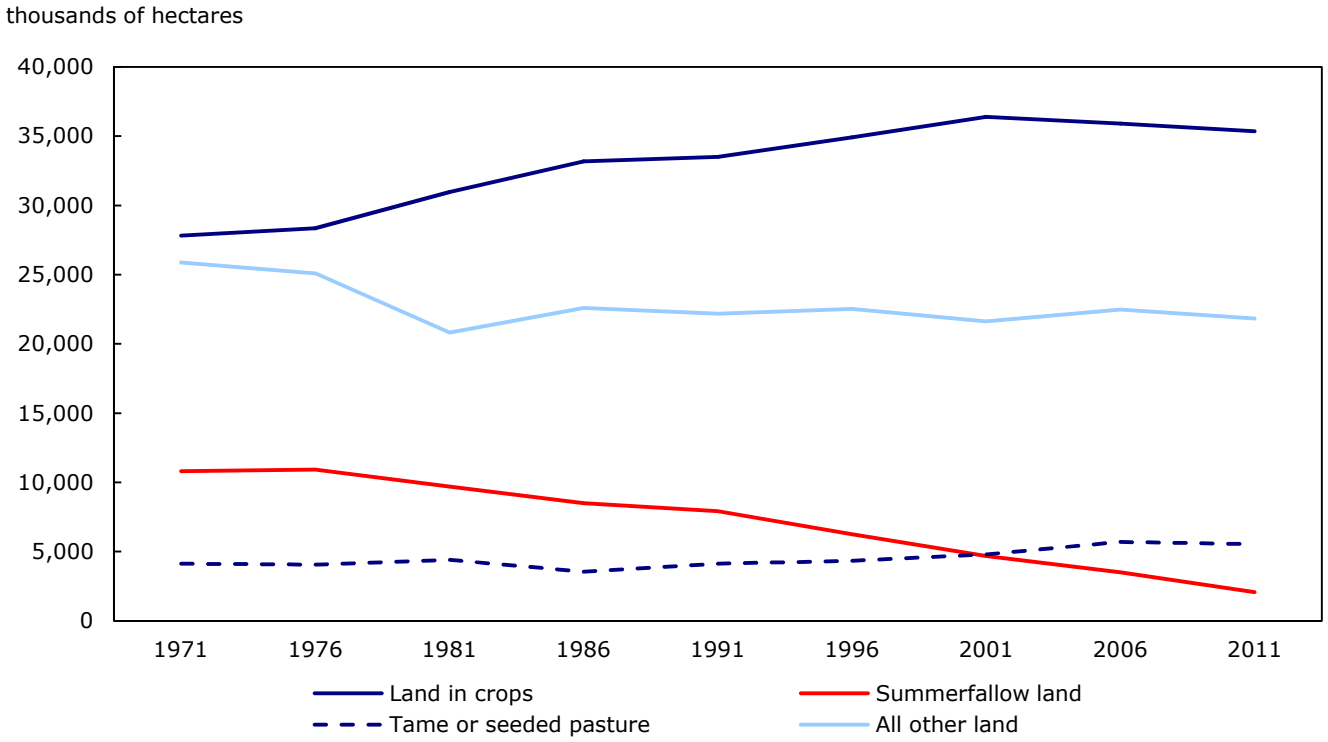
1. Excludes farms that do not have either an established environmental farm plan, or an environmental farm plan that is under review.
Note(s): Percentages may not add up to 100, due to rounding and/or non-response.
Source(s): Statistics Canada, 2013, *Farm Environmental Management Survey*, Catalogue no. 21-023-X.

5.2.1 Land use

Productive farmland is an essential component of agricultural ecosystems. Cropland—land producing field crops, hay, fruit, vegetables, sod and nursery crops—accounted for 55% of total farm area in 2011, followed by natural pasture (23%) and tame or seeded pasture (9%).[34] From 1971 to 2011, the area of cropland increased 27%, mainly as a result of large decreases in summerfallow (81%). Tame or seeded pasture areas increased 34%, while all other lands, including natural pasture, woodland and wetlands, idle land, and other lands decreased 16% (Chart 5.1).

34. Statistics Canada, 2012, *Farm and Farm Operator Data, 2011 Census of Agriculture*, Catalogue no. 95-640-X.

Chart 5.1
Land use, Canada, census years 1971 to 2011



Source: Statistics Canada, CANSIM table 004-0002 (accessed January 29, 2014). Statistics Canada, special tabulation of data from the 1971 Census of Agriculture.

5.2.2 Tillage and summerfallow practices

Proper land management can reduce erosion and increase soil structure and fertility, serving to preserve and enhance farmland. Agricultural soils that are covered, either by vegetation, crop residue or snow, are less susceptible to degradation by wind and water erosion. Tillage and summerfallow practices are two factors that determine how long soil is covered during the year. Other factors include the type of crop and the climate.

Tillage involves plowing and cultivating the soil in preparation for planting or seeding. Three types of tillage are commonly used in Canada. Conventional tillage incorporates or buries most of the previous year's crop residue into the soil. Conservation or minimum tillage retains most of the crop residue on the surface. No-till involves direct seeding into crop residue, avoiding any mechanical tillage of the soil.[35] Climate, soil and crop type all influence the type of tillage used. For example, cereal grains, oilseeds and beans can be easily grown using conservation or no-till practices while potatoes are generally grown using conventional tillage.

There are advantages to each of the three tillage practices. Conventional tillage loosens and aerates the soil, allowing for good air exchange and root growth. However, removing residues from the soil surface leaves soils more vulnerable to wind and water erosion and accelerates the decomposition of organic matter. Crop residues left on fields from conservation tillage and no-till conserve moisture, soil structure and organic matter. As well, conservation tillage and no-till involve fewer passes with machinery through fields, resulting in fuel and labour savings.

35. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, 1995, *The Health of Our Soils: Towards Sustainable Agriculture in Canada*, Acton, D.F. and L.J. Gregorich (eds.), Catalogue no. A53-1906/1995E, Ottawa.

Over the past 20 years conventional tillage has become less conventional, while no-till gained in popularity to become the number one option on farms nationally (this was particularly evident in Saskatchewan and Alberta).[36] Land prepared for seeding using conventional tillage decreased from 69% in 1991 to 19% in 2011 (Table 5.8). Land prepared for seeding using conservation tillage remained relatively unchanged at 24% in 1991 and 25% in 2011. No-till practices increased from 7% in 1991 to 56% in 2011. No-till practices were most common in the Prairies ecozone (64%) which contained 66% of the total area prepared for seeding in Canada.

36. Hoffman, N., 2008, "Conventional tillage: How conventional is it?" *EnviroStats*, Statistics Canada Catalogue no. 16-002-X, Vol. 2, no. 3.

Table 5.8
Tillage practices in Canada, by ecozone, 1991 and 2011

	1991				2011			
	Total area seeded			Total area prepared for seeding	Total area seeded			Total area prepared for seeding
	Conventional tillage	Conservation tillage	No-till		Conventional tillage	Conservation tillage	No-till	
	percent			hectares	percent			hectares
Canada	**69**	**24**	**7**	**29,028,766**	**19**	**25**	**56**	**29,580,090**
Taiga Plains	0	0	0	0	0	0	0	0
Boreral Shield	83	14	3	191,241	59	30	11	236,657
Atlantic Maritime	90	8	2	285,007	61	26	13	332,303
Mixed Wood Plains	80	17	3	3,096,730	39	31	30	3,658,129
Boreal Plains	80	18	1	5,102,600	20	31	49	4,731,481
Prairies	64	28	8	19,777,086	14	22	64	19,581,496
Pacific Maritime	86	5	8	28,331	71	16	14	27,089
Montane Cordillera	85	14	1	60,803	50	17	33	51,044

Note(s): Any differences between the results by ecozone and national totals are due to data suppression to protect confidentiality. See Statistics Canada, 2008, *Census of Agriculture: Environmental Geography Aggregations of Census Farm Units* (survey number 8012) for further details.
Source(s): Statistics Canada, CANSIM table 004-0010 (accessed February 3, 2014). Agriculture and Agri-Food Canada and Statistics Canada, special tabulation, Census of Agriculture, Census Geographic Component Base 2011 and Census of Agriculture Regular Base 1991.

Land use practices such as increased use of no-till practices and decreased area of summerfallow land have resulted in improvements in carbon sequestration due to higher soil organic matter retention,[37] and have also contributed to reductions in PM emissions.[38]

37. McConkey, B.G., D. Cerkowniak, W.N. Smith, R.L. Desjardins and M.J. Bentham, 2010, "Soil Organic Matter," pages 54 to 60 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.
38. Pattey, E., G. Qui and R. van Haarlem, 2010, "Particulate Matter," pages 126 to 131 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.

5.2.3 Nutrient and pest management

Canadian farmers are implementing a number of BMPs to manage nutrients. Practices such as regular soil testing and precision agriculture—managing crop production inputs on a site-specific basis—can increase the efficiency of nutrient use. Soil nutrient testing provides valuable information that producers can use to match crop nutrient requirements with nutrient levels in soil and nutrients applied in manure and commercial fertilizers. In 2011, soil nutrient testing was performed annually on 20% of crop farms while testing was done every two to three years on 36% of crop farms. Thirteen percent reported no soil nutrient testing (Table 5.9).

Table 5.9
Frequency of soil nutrient testing on crop farms, by province or region, 2011

	Frequency of soil nutrient testing				
	Every year	Every 2 to 3 years	Every 4 to 5 years	Every 6 years or more	Not tested
	percent				
Canada	**20**	**36**	**21**	**9**	**13**
Atlantic provinces	21	41	18	8	11
Quebec	13	35	49	F	F
Ontario	12	49	21	9	9
Manitoba	31	35	13	8	13
Saskatchewan	19	26	19	13	23
Alberta	31	31	13	10	13
British Columbia	29	28	16	10	16

Note(s): Percentages may not add up to 100, due to rounding and/or non-response.
Source(s): Statistics Canada, 2014, Farm Environmental Management Survey, special tabulation.

To reduce the use of pesticides, farmers are also using a number of alternative methods of pest control. In 2011, 55% of crop farms used crop rotation to disrupt pest cycles, with more than half of the crop farms in Ontario, Saskatchewan, Manitoba and Alberta using this method of pest control (Table 5.10).

Table 5.10
Alternative methods of pest control on crop farms, by province or region, 2011

	Plant crop varieties that are resistant to specific pesticides	Rotate crops to disrupt pest cycles	Eliminate, remove or incorporate diseased plants, pruning residues or cull piles	Use fall planted species (e.g., winter wheat, fall rye)	Use tillage implements	Mowing	Use hand weeding/ hoeing	Use covers/ mulches	Introduce natural enemies/ biological control agents	Use lure or trap crops	Other	None
	percent											
Canada	**31**	**55**	**15**	**12**	**36**	**26**	**15**	**6**	**2**	**30**	**3**	**17**
Atlantic provinces	17	38	28	8	31	51	26	15	4	18	7	14
Quebec	29	48	14	5	29	34	20	6	2 E	28	3	22
Ontario	42	63	20	26	43	32	21	10	2	40	3	12
Manitoba	36	58	16	14	54	22	8	5	2	33	2 E	14
Saskatchewan	31	62	10	6	33	13	6	3	2	28	3	16
Alberta	23	52	12	4	31	22	13	3	1 E	23	3	19
British Columbia	12	19	24	8	23	38	31	17	8	16	5	26

Source(s): Statistics Canada, 2014, Farm Environmental Management Survey, special tabulation.

5.2.4 Grazing livestock management

Keeping livestock in an open field during the late fall and winter period—a practice referred to as extended grazing—allows manure to be deposited directly rather than using a manure spreader. However, care must be taken to ensure the deposits are spread throughout the landscape, to ensure that overgrazing does not occur and also to ensure that environmentally sensitive areas are avoided. Regularly moving feed, shelter and bedding sites help to achieve this.

In 2011, 39% of livestock farms practised extended grazing (Table 5.11). This proportion was highest in the western provinces, particularly Saskatchewan (65%) and Alberta (62%), where cattle farming is common, and lowest in Quebec (6%), where dairy operations are more prevalent.

Table 5.11
Proportion of livestock farms practising extended grazing, by province or region, 2011

	Livestock farms practising extended grazing
	percent
Canada	**39**
Atlantic provinces	17
Quebec	6
Ontario	17
Manitoba	54
Saskatchewan	65
Alberta	62
British Columbia	45

Note(s): Livestock kept in an open field during the late fall and winter period is a farming practice commonly referred to as extended grazing.
Source(s): Statistics Canada, 2013, *Farm Environmental Management Survey*, Catalogue no. 21-023-X.

Controlling livestock access to surface water prevents stream bank degradation and protects water quality. In 2011, 56% of livestock farms had pastures or grazing paddocks adjacent to surface water (Table 5.12). This proportion was highest in Saskatchewan (74%) and lowest in Quebec (33%). In 2011, 15% of livestock farms allowed no access to surface water, 18% allowed limited access, and 35% allowed unlimited access during the grazing season (Table 5.13). The proportion of livestock farms allowing no access was highest in Quebec (66%) while the proportion allowing unlimited access for the entire grazing season was highest in Manitoba (43%) and Saskatchewan (41%).

Table 5.12
Proportion of livestock farms with pastures or grazing paddocks adjacent to surface water, by province or region, 2011

	Livestock farms with pastures or grazing paddocks adjacent to surface water
	percent
Canada	**56**
Atlantic provinces	49
Quebec	33
Ontario	37
Manitoba	59
Saskatchewan	74
Alberta	63
British Columbia	56

Source(s): Statistics Canada, 2013, Farm Environmental Management Survey, special tabulation.

Table 5.13
Proportion of livestock farms allowing grazing livestock access to surface water, by province or region, 2011

	Unlimited year round access	Unlimited access for the entire grazing season	Unlimited access for the winter feeding season	Limited access	No access
	percent				
Canada	**32**	**35**	**1**	**18**	**15**
Atlantic provinces	14	33	x	19	33
Quebec	6 E	7 E	0	21	66
Ontario	12	21	x	33	34
Manitoba	33	43	F	16	7
Saskatchewan	45	41	F	11	3
Alberta	33	39	1 E	17	9
British Columbia	33	31	F	20	14

Note(s): Percentages may not add up to 100, due to rounding and/or non-response.
Source(s): Statistics Canada, 2014, Farm Environmental Management Survey, special tabulation.

5.2.5 Other land and water management practices

Farmers have adopted a number of other BMPs that can improve farmland productivity and reduce environmental impacts. According to the most recent Farm Environmental Management Survey, 24% of farms had permanent perennial forages on erodible land, 20% used slow release fertilizer products and 18% added straw to improve soil condition in 2011. Cover or companion crops were used on 15% of farms and 9% planted winter cover or green manure crops (Table 5.14).

Table 5.14
Land management practices on Canadian farms, by province or region, 2011

	Cover or companion crops	Winter cover or green manure	Terracing, contour or across the slope cropping	Permanent perennial forages on erodible land	Adding straw to improve soil condition (e.g., mulching)	Placing eroded soil back on hilltops	Controlled or slow release nitrogen fertilizer products (e.g., urease inhibitors, ESN technology) [1]	Field shelterbelts or windbreaks	Surface or sub-surface drainage of land	Restore or plug previously drained wetlands to natural condition	Other
	percent										
Canada	**15**	**9**	**5**	**24**	**18**	**5**	**20**	**26**	**31**	**4**	**5**
Atlantic provinces	15	12	12	28	13	8	18	33	34	4	6
Quebec	23	13	6	19	8	5	20	19	53	4	6
Ontario	22	16	6	22	21	5	26	28	51	4	6
Manitoba	10	7	3	27	20	7	17	31	32	4	4
Saskatchewan	7	4	4	27	17	5	16	24	13	5	4
Alberta	10	4	3	27	24	5	17	29	14	4	5
British Columbia	19	11	4	23	13	4	26	15	18	5	5

1. Crop farms only.
Source(s): Statistics Canada, 2014, Farm Environmental Management Survey, special tabulation.

Producers in many provinces are required by regulation to maintain setback distances from water bodies. Riparian buffer areas—located on the banks of a river, stream, lake or other water body—help capture soil, nutrients and pesticides from running off farms, as well as providing stability to shorelines.[39] In 2011, more than half (54%) of farms with waterways maintained a riparian buffer for all of these waterways while 23% of producers with seasonal wetlands and 41% with

39. MacKay, R. and J. Hewitt, 2010, "Farm Environmental Management," pages 20 to 30 in Eilers, W., R. MacKay, L. Graham and A. Lefebvre (eds.), 2010, *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series—Report #3*, Agriculture and Agri-Food Canada, Ottawa.

permanent wetlands maintained a riparian buffer area for all of them (Table 5.15). This practice was most common in the Atlantic provinces, Quebec and Ontario.

Table 5.15
Farms with surface water bodies maintaining riparian buffer areas around or beside surface water bodies, by province or region, 2011

	Seasonal wetlands			Permanent wetlands			Waterways		
	Yes, all	Yes, some	No	Yes, all	Yes, some	No	Yes, all	Yes, some	No
	percent								
Canada	**23**	**12**	**65**	**41**	**12**	**47**	**54**	**10**	**35**
Atlantic provinces	51	10	39	65	8	27	64	12	25
Quebec	46	12 E	42	63	F	34	84	6	10
Ontario	39	8 E	53	63	F	33	64	10	26
Manitoba	18	14	68	32	16	51	36	18	46
Saskatchewan	17	12	71	33	13	54	26	12	62
Alberta	21	13	66	40	13	47	38	11	50
British Columbia	35	13	52	45	9	46	48	13	39

Note(s): Percentages may not add up to 100, due to rounding and/or non-response.
Source(s): Statistics Canada, 2014, Farm Environmental Management Survey, special tabulation.

Irrigators use a variety of practices to conserve water. In 2012, some of the most common practices used by irrigators were watering at night or in the morning, using water or energy saving nozzles, incorporating compost or other organic material into the soil or leaving stubble on fields to help retain moisture, and reducing irrigation water pressures.[40]

Farms in the South Saskatchewan drainage region were the most likely to use water or energy saving nozzles, to reduce irrigation water pressure and to conserve moisture by leaving crop stubble and incorporating organic matter into soils. Watering at night or in the morning was particularly common in the Great Lakes, the Okanagan–Similkameen and the Fraser–Lower Mainland.

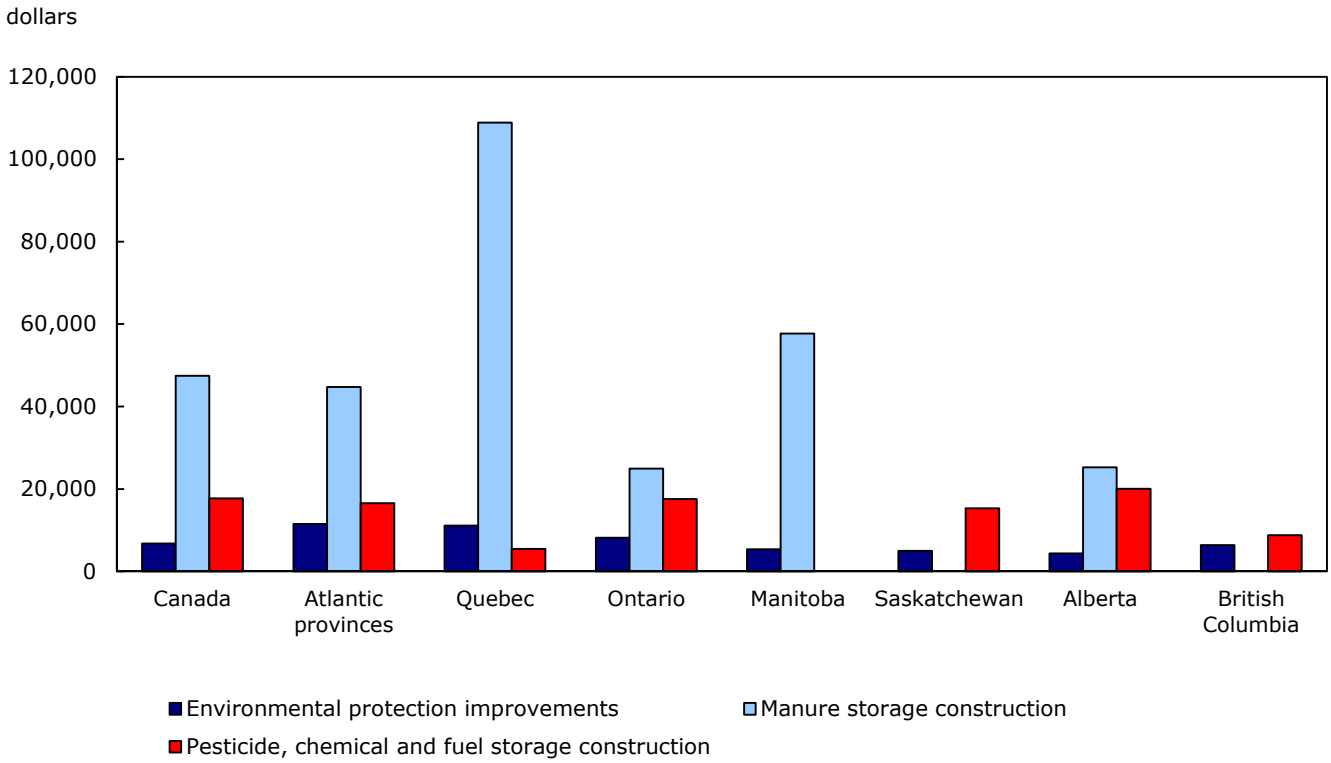
40. Statistics Canada, 2013, *Agricultural Water Use in Canada, 2012*, Catalogue no. 16-402-X.
41. Éditeur officiel du Québec, 2005, *Règlement sur les exploitations agricoles*, Chapitre III, Section II, *http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=3&file=/Q_2/Q2R26.HTM* (accessed September 15, 2014).

5.2.6 Capital investments

Farmers also make investments to offset their environmental impacts. According to the Farm Financial Survey, farmers who reported capital investments in 2011, invested an average of $6,810 per farm on environmental protection improvements, an average of $47,480 on manure storage construction and an average of $17,701 on pesticide, chemical and fuel storage construction (Chart 5.2). The higher investment in manure storage in Quebec is related to regulatory requirements, the type of storage structure required for liquid manure, and the large number of dairy and hog operations in the province.[41,42,43]

42. Beaulieu, M.S., 2004, "Manure Management in Canada," *Farm Environmental Management in Canada*, Statistics Canada Catalogue no. 21-021-M, Vol. 1, no. 2.
43. Bourque, L., and R. Koroluk, 2003, "Manure storage in Canada," *Farm Environmental Management in Canada*, Statistics Canada Catalogue no. 21-021-M, Vol. 1, no. 1.

Chart 5.2
Selected capital investments, average per farm reporting, by province or region, 2011



Note: Environmental protection improvements include shelterbelts, windbreaks, buffer strips or fences for waterways protection. Manure storage construction data for Saskatchewan and British Columbia and pesticide, chemical and fuel storage construction data for Manitoba are not shown because they have a data quality code of F.

Source: Statistics Canada, Agriculture Division, 2014, special tabulation.

Section 6

Environmental accounting—bringing it all together

The agriculture industry, along with fishing and forestry industries, occupies a unique position at the interface of the environment and the economy. These industries, like all others, employ labour and capital in the production of their outputs, but they also depend to a large extent on natural processes that contribute to the biomass yields that they harvest. Because of this clear dependence on ecosystem services, these industries represent an ideal opportunity to apply the environment-economy accounting approaches developed through the System of Environmental-Economic Accounting (Textbox 6).

Textbox 6: System of Environmental-Economic Accounting (SEEA)

The Central Framework of the United Nations System of Environmental-Economic Accounting (SEEA Central Framework) was adopted as an international statistical standard in 2012. This represented the culmination of 20 years of work on the concepts and methods related to environmental accounting. The following year, two other publications were welcomed by the Statistical Commission of the United Nations, namely SEEA-Applications and Extensions, and SEEA-Experimental Ecosystem Accounting. While these later two publications are not yet developed to the level of a statistical standard, they do provide advice on the best practices currently available in their respective subject matter domains and expand the SEEA beyond its initial scope.

The SEEA Central Framework is built around three main areas of accounting: physical flow accounts, asset accounts, and environmental activity accounts. Physical flow accounts record the supply and use of natural inputs (e.g., water), products (e.g., milled grain), and residuals (e.g., manure).

These accounts represent an extension of the standard economic supply and use tables. Firstly, they are provided in physical as opposed to monetary units of measure. Asset accounting looks at the stock of natural resources, providing measures of both the quantity and value of natural resource wealth. The SEEA Central Framework covers non-produced assets—in an agricultural context this would mean farmland—as opposed to the produced assets (e.g., buildings and equipment) covered in the standard economic accounts. Finally, environmental activity accounts show expenditures related to both environmental protection and to the management of natural resources. These expenditures are part of the standard national accounts measures, but they are made explicit here to highlight expenditures related to improving and managing the environment.

To make this environmental linkage explicit, the Food and Agriculture Organization of the United Nations (FAO) is extending the accounting principles described in the SEEA Central Framework to propose a new set of accounts focused on showcasing the economic-environmental links of the farming, fishing, and forestry industries. These accounts will cover such topics as pesticide use, crop production, greenhouse gas emissions and land cover change, among others. Other relevant areas under consideration include economic data (e.g., employment and value added) and soil resources (e.g., soil classification, erosion and soil quality). The work is expected to yield a set of inter-related tables and accounts with key agri-environmental indicators that will be relevant to the analysis of the agriculture, fishing, and forestry sectors in all countries.

Table 6.1 provides an example of one aspect of the SEEA-Agriculture accounts, namely the tracking of physical flows of agricultural goods in a supply and use framework.[1] As shown in this table, Canada's crop production was heavily based, by weight, on cereals including wheat and corn, as well as on canola, soybeans and potatoes, among other crops in 2011. Tomatoes and apples were the most important vegetable and fruit crops produced domestically.

1. This table is based largely on Statistics Canada's existing data on supply and disposition of food, grains and corn (CANSIM tables 002-0010, 001-0041 and 001-0042), but has been supplemented with data from other administrative and external sources in order to provide additional detail for some uses.

In 2011, two-thirds (66%) of domestic wheat production was exported to other countries. The remainder was used on farms for seeding purposes or as livestock feed, was used in the food manufacturing industry, or was used to produce energy.

The bulk of tame hay produced in Canada is used on farms for livestock feeding. Corn is used on farms or processed by the food manufacturing industry. Most canola and soybean production is processed in Canada or sent for export.

Canada imports much of its fruit and vegetable supply in order to meet its domestic demand. In particular, the table shows high imports and low exports for onion and shallots, apples and grapes. Almost the entire production of tree nuts is exported. Most domestic nut consumption is supported by imports.

This summary table and the more detailed table in Appendix A are initial tests of the classifications, definitions, and accounting relationships being proposed in SEEA-Agriculture and highlight some of the current data gaps in this area of accounting, as evidenced by the significant amount of stock variation for some commodities. More detailed tables and guidelines that cover the forestry and fishing sectors are also being prepared. In the end, this effort will cover environmental assets and transactions in addition to the physical flow data shown here. Statistics Canada will contribute to the testing and development of these international guidelines as the work continues.

Table 6.1

Crop and crop product physical flows of selected domestically produced commodities, Canada, 2011

	Supply			Demand					
	Output (domestic production)	Imports	Total supply	Industry intermediate consumption [1]	Household consumption	Waste	Exports	Stock variation	Total use
	thousands of tonnes								
Cereals and related products									
Tame hay	27,735	..	**27,735**	27,735	..	..	..	0	**27,735**
Wheat	25,288	64	**25,352**	8,628	..	33	16,651	41	**25,312**
Corn (corn fresh, corn for grain and fodder corn)	20,555	1,313	**21,868**	12,075	127	11	1,053	8,601	**13,267**
Oilseeds									
Canola	14,608	146	**14,754**	7,081	0	1	7,901	-228	**14,982**
Sunflower seed	20	31	**51**	0.10	..	..	43	8	**43**
Pulses									
Soybeans	4,467	293	**4,760**	1,572	..	..	2,556	633	**4,127**
Peas (dry and fresh)	2,545	28	**2,573**	206	10	1	2,855	-499	**3,072**
Lentils	1,574	15	**1,589**	87	..	..	1,161	341	**1,248**
Roots, tubers and related crops									
Potatoes [2]	4,189	266	**4,456**	2,414	761	667	614	0	**4,456**
Sugar beets [3]	931	..	**931**	703	..	..	228	0	**931**
Carrots	412	114	**526**	115	292	9	98	12	**514**
Other vegetables and related crops									
Tomatoes (field and greenhouse)	738	194	**932**	435	302	53	142	0	**932**
Onions and shallots fresh	201	178	**379**	0	318	20	30	10	**369**
Cucumbers (field and greenhouse)	266	50	**316**	37	187	16	76	0	**316**
Fruits and related crops									
Apples	395	199	**593**	152	432	18	24	-33	**627**
Blueberries	105	46	**151**	79	51	2	20	0	**151**
Grapes (table and wine)	90	178	**268**	88	162	16	2	0	**268**
Tree nuts									
Tree nuts	0.34	57	**58**	..	57	..	0.31	0	**58**

1. Includes the following categories: agricultural (feed), agricultural (seed), and manufacturing (food, energy and other)
2. Industry intermediate consumption for potatoes (demand for seed and manufacturing uses) was estimated using ratios on seeding and manufacturing using data from Prince Edward Island and applying this value for Canada.
3. Sugar beets are produced in Alberta and Ontario. Alberta's output (CANSIM table 001-0010) is transformed within Canada, while Ontario's output is exported. The 2011 production for Ontario (export) was estimated by multiplying the area harvested (residual from the 2011 Census of Agriculture and CANSIM table 001-0010) by Alberta's 2011 production per hectare.

Note(s): Available data on demand for agricultural commodities were occasionally published only in an aggregated format and could not be separated into the different components presented in this table. For this reason, data for the categories, 'agricultural feed, ''food manufacturing, ''household consumption' and 'waste' are found under 'stock variation' for soybean, dry peas, lentils and sunflower seed.

Source(s): Statistics Canada, CANSIM tables 001-0010, 001-0041, 001-0042, 002-0010 and 004-0003 (accessed March 27, 2014). PEI Potatoes, n.d. (no date). *Potato Industry*, *http://www.peipotato.org/potato-industry* (accessed April 29, 2014). Buzzanell, P., 2011, "Sugar, HFCS & Ethanol in Canada: An Overview," *Sugarbeet Grower*, Vol. 50, no. 2, pages 16 to 18, *http://issuu.com/forumprinting/docs/sugarbeet_grower_magazine_feb_2011* (accessed May 9, 2014).

Section 7

Conclusion

Canada's ecological infrastructure—its land, soil, water and climate—provide the foundation for agricultural activity in Canada. Ecosystem functions, such as biomass production and nutrient cycling, are necessary inputs into agriculture and together along with human efforts and ingenuity contribute to producing a wide array of food and other products benefitting Canadians and others worldwide.

Agriculture is at the interface of ecosystems and economic activity. Farmers manage ecosystems to produce agricultural goods including crops and livestock. This output benefits Canadians and consumers around the world. Some farm activities can have negative environmental impacts, but various management practices can be used to mitigate problems and restore ecological infrastructure, which influence the flow of ecosystems goods and services from agricultural landscapes.

This report helps develop understanding of the linkages between each of these different components of Canada's agricultural sector and its reliance on ecosystems. It also brings us back to the start of our discussion, where we introduced the Ecosystem Goods and Services conceptual framework (Figure 1.1). Further work is needed in order to better quantify the inputs required to produce agricultural goods, other ecosystem services generated by agricultural ecosystems and the impacts of agricultural activities on land use and changes in environmental condition.

Appendix A

Crop and crop product physical flows

Table 1
Crop and crop product physical flows of selected domestically produced commodities, Canada, 2011

	Supply					Demand								
	Output (domestic production)			Imports	Total supply	Industry intermediate consumption			Household Consumption		Waste	Exports	Stock variation	Total use
	Gross production	Harvest losses	Agricultural Industry			Agricultural (feed)	Agricultural (seed)	Manufacturing (food, energy and other)	Food	Other uses				
	thousands of tonnes													
Cereals and related products														
Tame hay	..	..	27,735	..	27,735	27,735	..	..	..	..	..	..	0	27,735
Wheat	..	..	25,288	64	25,352	4,237	874	3,517	..	..	33	16,651	41	25,312
Corn (corn fresh, corn for grain and corn fodder)	..	..	20,555	1,313	21,868	6,724	14	5,338	127	..	11	1,053	8,601	13,267
Oilseeds														
Canola	..	..	14,608	146	14,754	414	55	6,611	0	..	1	7,901	-228	14,982
Sunflower seeds	..	..	20	31	51	..	0.10	..	..	..	..	43	8	43
Pulses														
Soybean	..	..	4,467	293	4,760	..	163	1,409	..	..	..	2,556	633	4,127
Peas (dry and fresh)	..	..	2,545	28	2,573	..	166	40	10	..	1	2,855	-499	3,072
Lentils	..	..	1,574	15	1,589	..	87	..	..	..	..	1,161	341	1,248
Root, tubers and related crops														
Potatoes [1]	..	..	4,189	266	4,456	..	345	2,069	761	..	667	614	0	4,456
Sugar beets [2]	..	..	931	..	931	..	..	703	..	..	..	228	0	931
Carrots	..	..	412	114	526	..	..	115	292	..	9	98	12	514
Other vegetables and related crops														
Tomatoes (field and greenhouse)	..	..	738	194	932	..	..	435	302	..	53	142	0	932
Onions and shallots fresh	..	..	201	178	379	..	..	..	318	..	20	30	10	369
Cucumbers (field and greenhouse)	..	..	266	50	316	..	..	37	187	..	16	76	0	316
Fruits and related crops														
Apples	..	..	395	199	593	..	..	152	432	..	18	24	-33	627
Blueberries	..	..	105	46	151	..	..	79	51	..	2	20	0	151
Grapes (table and wine)	..	..	90	178	268	..	..	88	162	..	16	2	0	268
Tree nuts														
Tree nuts	..	..	0.34	57	58	..	..	..	57	..	..	0.31	0	58

1. Agricultural seed and manufacturing consumption for potatoes was estimated using ratios on seeding and manufacturing using data from Prince Edward Island and applying this value for Canada.
2. Sugar beets are produced in Alberta and Ontario. Alberta's output (CANSIM table 001-0010) is transformed within Canada, while Ontario's output is exported. The 2011 production for Ontario (export) was estimated by multiplying the area harvested (residual from the 2011 Agriculture Census and CANSIM table 001-0010) by Alberta's 2011 production per hectare.

Note(s): Available data on demand for agricultural commodities was sometimes published only in an aggregated format and could not be separated into the different components presented in this table. For this reason, data for the categories, 'agricultural feed, ''food manufacturing, ''household consumption' and 'waste' are found under 'stock variation' for soybean, dry peas, lentils and sunflower seed.

Source(s): Statistics Canada, CANSIM tables 001-0010, 001-0041, 001-0042, 002-0010 and 004-0003 (accessed March 27, 2014). PEI Potatoes, n.d. (no date), *Potato Industry*, *http://www.peipotato.org/potato-industry* (accessed April 29, 2014). Buzzanell, P., 2011, "Sugar, HFCS & Ethanol in Canada: An Overview," *Sugarbeet Grower*, Vol. 50, no. 2, pages 16 to18, *http://issuu.com/forumprinting/docs/sugarbeet_grower_magazine_feb_2011* (accessed May 09, 2014).

Appendix B

Glossary

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

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

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

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

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

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

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

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

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

Farm area: the category 'Total farm area' from the Census of Agriculture—this includes the following land use categories: cropland, summerfallow, tame or seeded pasture, natural pasture and 'all other land.'

Farmland: land that is used for agriculture, including cropland, summerfallow and pasture lands.

Greenhouse gas emission intensity: the volume of greenhouse gases (GHGs) emitted per unit of production.

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

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

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

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

Regulating services: ecosystem services that regulate climatic, hydrological and bio-chemical cycles, as well as biological processes.

Renewable water: the volume of water that supplies aquifers and/or surface water bodies that is replenished in an average year by precipitation.

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

Runoff: the portion of precipitation and melt from snowpack and glaciers that, by a variety of paths above and below the surface of the ground, reaches the stream channel. Once it enters a stream channel, runoff becomes **streamflow**.

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

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

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

Water use: is the amount of water withdrawn from water resources to support society in both the economic and residential sectors.

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

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