



<a href="#">The Green Lane</a>	<a href="#">Search</a>	<a href="#">Contact Us</a>	<a href="#">Français</a>	<a href="#">Canada Site</a>
<a href="#">Sustainable Development</a>	<a href="#">Monographs</a>	<a href="#">Splash Page</a>	<a href="#">Français</a>	

# CULTIVATING A SECURE FUTURE

## Rural Development and Sustainable Agriculture in Canada

*A Canadian contribution to the land use dialogue at the Eighth Session of  
the United Nations Commission on Sustainable Development, April 24 to  
May 5, 2000*

---

### Contents

---

#### [PREFACE](#)

#### [INTRODUCTION](#)

#### [RURAL DEVELOPMENT](#)

[A Glimpse at Rural Canada](#)

[New Approaches in Rural Development](#)

#### [SUSTAINABLE AGRICULTURE](#)

[The Importance of Agriculture in Canada](#)

[Working Toward Sustainable Agriculture](#)

[The Role of Government](#)

[The Role of the Agriculture and Agri-Food Sector](#)

[The Role of the Community](#)

[International Cooperation](#)

[The State of Resources Affected by Agriculture](#)

[Soil Quality](#)

[Water Issues](#)

[Air Issues](#)

[Agroecosystem Biodiversity](#)

[Production Intensity](#)

[NEXT STEPS](#)

[CONCLUSION](#)

[SELECTED READINGS](#)

[WEB SITES](#)

---

# Preface

---

At its eighth session in the spring of 2000, the United Nations Commission on Sustainable Development (CSD) will be reviewing global progress made with respect to Chapter 10 of Agenda 21, "Integrated Approach to the Planning and Management of Land Resources". For Canada — the world's second largest country in land mass — the issues associated with the sustainable development of land resources are intimately entwined with Canadian history, in addition to being pivotal to its future well-being. As a contribution to the land use dialogue, Canada has prepared a series of six monographs describing its experience and the challenges that remain in the integration of sustainable development.

Agriculture and forests will be particular themes at CSD 8. Canada is world famous for its prairie wheat, and sustainable agricultural practices, both within Canada and internationally, have global implications. Canada presents its experiences in its first monograph on sustainable agriculture. As with the prairies, images of vast Canadian forests and the rugged Canadian Shield rich in minerals are familiar Canadian icons. For this session of the CSD, Canada has updated monographs on forests and on minerals and metals originally prepared for the five-year review of Agenda 21 in 1997.

Canada, along with its circumpolar neighbours, faces extraordinary challenges in the sustainable development of its Arctic regions. It is working to this end directly with Indigenous peoples and

territorial governments, including the newest territory, Nunavut, which came into being on April 1, 1999. Along with fellow members of the Arctic Council, Canada is looking for means to ensure that the world has a better understanding of the impact of southern activities on the vulnerable Arctic environment. In this regard, a monograph addressing sustainable development and Indigenous peoples in the Canadian Arctic has been prepared.

Key to successfully implementing sustainable development policy is a clear understanding of the issues to be addressed. The role of science cannot be underestimated in this search for understanding. In this regard, Canada has developed two additional monographs. One provides an overview of the applications of earth sciences to the gathering and interpretation of scientific information to contribute to policy development. In the other, Canada concludes its monograph series for CSD 8 with a review of its experiences of an ecosystem approach to the development of sustainable development principles.

This monograph reports on Canadian progress on items under Chapter 14 of Agenda 21 relating to sustainable agriculture and rural development with a view to increasing food production in a sustainable way and enhancing food security. It begins with a broad description of current government approaches to rural development in Canada, emphasizing that sustainable rural development depends not so much on sustainable agriculture as on economic diversification. At the same time, sustainable agriculture, built on an ecosystem approach, is the key to protecting the natural resources on which agriculture depends, as well as an important component of food security in Canada and abroad. This monograph describes Canadian developments toward sustainable agriculture, acknowledging the three-fold nature of sustainable development — social, economic, and environmental — but concentrating on advances being made with respect to environmental sustainability. It concludes with a list of the next steps that can be taken to move Canada further along in stabilizing and building rural communities and ensuring that agriculture can be practised profitably and in an environmentally sound way in the years to come.

Canada is a vast dominion, divided into ten provinces and three territories and bordering three oceans. It has three levels of government — federal, provincial or territorial, and municipal — along with emerging Aboriginal government structures. The federal government has jurisdiction over matters of national interest, and the provinces and territories over matters of particular interest, such as health and education. Thus, both the federal and provincial/territorial governments have an interest in rural development and the practice of agriculture. The discussion in this monograph focuses mainly on federal initiatives for rural development and sustainable agriculture, but illustrates provincial activities along these lines and occasionally draws from municipal and industry examples to show community-level efforts.

Many federal and provincial government agencies, civil groups, and individuals helped guide the development of this monograph, contributed material, or provided insightful reviews. This cooperation aptly illustrates the importance of partnerships in all efforts to achieve sustainable rural development and agriculture in Canada, from the planning stages to its realization in the field.

For Canada, sustainable development is best represented as a journey, not a destination. The monographs described above, as well as the other monographs in the Sustainable Development in Canada Monograph Series, are milestones on this journey, and we invite you to join us and share our experiences.

# INTRODUCTION

Around the globe today there is renewed national interest in rural development. With the world population projected to grow to 8 billion people by 2025, increasing food production sustainably becomes an urgent issue, as does the well-being of people living in rural areas. Although rural development often brings to mind agricultural production and natural resource management, today it involves much more than that. The broad goal of rural development is rural growth focusing on the needs of people — their access to knowledge, research products and technologies, markets, health care, education, financing, and land ownership.

## Rural Development

### A Glimpse at Rural Canada

Rural Canada comprises more than 90 percent of Canada's total land area. Its geography is highly diverse, including coastlands, farmlands, forests, and the northern hinterlands. Many of the economic activities taking place in rural settings, such as forestry, fishing, agriculture, the energy industry, and mining, are based on the wealth of natural resources found there. But newer industries, including service and distribution, recreation and tourism, and manufacturing, join resource-based employment to make the rural economy as diverse as the landscape.



*Photo credit: Marc LaJoie.*

Early in Canada's national history, as much as 80 percent of the population was occupied with farming and lived in the countryside. With the industrial revolution and particularly the coming of the national railroad, many rural people established villages and towns or migrated to cities, especially in eastern Canada. Today, only about 3 percent of Canadians are directly involved in farming, but about 30 percent live in rural and remote regions and carry out their businesses there. They support a rural economy that underpins the urban economy, and more than any other Canadians, have the responsibility of managing Canada's natural resources wisely.

Rural people share many interests, goals, and needs with city dwellers, but they also have unique challenges. Many communities have seen their populations falter as employment opportunities decline. Economic diversification is often the key to community sustainability, but the resources to achieve this goal may not always be available. An important goal of sustainable rural development is building the capacity of rural peoples and communities to determine their own futures.

## New Approaches in Rural Development

In its March 1997 report *Think Rural!*, the House of Commons Standing Committee on Natural Resources urged the Government of Canada to develop a comprehensive and regionally focused rural policy for Canada. In the Speech from the Throne, September 1997, the Government of Canada made such a commitment, which has taken form in the Canadian Rural Partnership. This innovative cross-government approach is aimed at coordinating federal programs, policies, and activities in support of rural communities. As its name implies, it depends on the cooperative work of many partners. An interdepartmental working group representing 26 federal departments and agencies designs and carries out the initiative, aided by rural teams in all provinces and territories. These teams build partnerships, networks, and alliances with rural people and their communities to address key rural issues.

Hearing the views of rural Canadians was the first step in ensuring that government action is relevant to rural needs and concerns. As part of the Canadian Rural Partnership initiative in 1998, rural Canadians were invited to make their views known through the

### Features of Rural Canada

*The population in Canada's rural and remote areas increased between 1981 and 1996, reaching nearly 9 million people. However, because of the higher growth in major urban centres, the share of Canada's population in rural and remote areas declined over this period, from 34 to 31 percent. The population of rural areas adjacent to major urban centres has generally grown during this period, while that of more distant areas has declined. The population of young people is declining in rural areas because of declining birth rates, an aging population, and the migration of young families to cities. Compared to more populated areas of Canada, rural areas have lower employment rates for all age groups; lower per capita income but per capita real income growth above the national average; more hospital beds but fewer physicians per 1000 people; and lower levels of formal education. The Canadian average masks considerable regional variation.*

### Rural Dialogue in Ontario

*In April 1998, The Ontario Rural Council (TORC) was launched to act as a catalyst for rural dialogue, collaboration, and action to meet the needs and unite the voices of rural Ontario. The council comprises more than 40 members representing a cross-section of rural sectors — economics and infrastructure, resources and the environment, community and human services, government, and members at large. Similar multistakeholder partnerships have been developed in other provinces, such as Quebec's Solidarité Rurale and the Saskatchewan Council for Community Development.*

Rural Dialogue. As a result of this interaction, the federal government produced the Federal Framework for Action in Rural Canada, which identifies 11 priority areas for government action (see box below). A significant component of the Canadian Rural Partnership is to promote and foster a greater inclusion of rural considerations in federal policies and programs. All new policies and programs of the federal government are scrutinized through a "rural lens" to assess their effects on rural Canada.

### **Rural Canadians Identify Priorities for Rural Development**

Through the Rural Dialogue, rural Canadians identified the following 11 priorities for the Government of Canada in their work to promote rural development:

- improve access to federal government programs and services for rural Canadians
- improve access to financial resources for rural business and community development
- provide more targeted opportunities, programs, and services for youth, including Aboriginal youth
- strengthen rural community capacity building, leadership, and skills development
- create opportunities for rural communities to maintain and develop infrastructure for community development
- connect rural Canadians to the knowledge-based economy and society and help them acquire the skills to use the technology
- strengthen economic diversification in rural Canada through more targeted assistance
- work with provincial and territorial governments to examine and pilot-test new ways to provide rural Canadians with access to health care at reasonable cost
- work with provincial and territorial governments to examine and pilot-test new ways to provide rural Canadians with access to education at reasonable cost
- foster strategic partnerships within communities, between communities, and among governments to facilitate rural community development
- promote rural Canada as a place to live, work, and raise a family, recognizing the value of rural Canada to the identity and well-being of the nation

A Pilot Projects Initiative was begun in 1998 to support rural Canadians as they engage in creative activities that promote sustainable community development. In 1998–1999, 68 projects were funded across Canada, and 70 more were approved for funding in 1999–2000. Pilot projects already under way have been carried out in cooperation with strategic groups from the private sector, the voluntary sector, cooperatives, and other stakeholders and levels of government. The pilot projects are varied, relating, among other themes, to community use of information technology, rural youth and Aboriginal peoples, and exploration of new value-added initiatives for rural and remote communities. For example, the Yukon On-line Project is improving the use of the Internet as a tool for commerce in remote communities in Yukon. Three communities — Haines Junction, Mayo, and Watson Lake — now receive Internet service through Yukon College. The Atikokan Fish Co-op in northern Ontario is developing a toolkit and model business plan to replicate cooperative fish farming in rural communities. This co-op is unique in operating a commercial fish farm on the site of an abandoned open pit mine, successfully converting an environmental liability into an asset.

Promoting rural development is also one of the objectives of *Gathering Strength*, Canada's action plan for better cooperation with Aboriginal groups — to support strong communities, peoples, and economies. Through the Canadian Rural Partnership's Pilot Projects Initiative, Aboriginal peoples have received help in establishing small rural businesses. For example, the Eel Bar First Nation in New Brunswick has run a pilot project to assess the potential for commercial production of indigenous medicinal and aromatic plant species. Ways of reducing the barriers to Aboriginal involvement in agricultural development are also being examined.

Provincial and territorial governments also have initiatives in place to promote rural development. Alberta Management Insight is a joint venture among the Agriculture Financial Services Corporation; Alberta Agriculture, Food and Rural Development; and the Alberta Farm Business Management Initiative. Under this venture, cropping information collected from 15 000 farmers for insurance purposes will be built into an agricultural database and distributed to farmers to help them make cropping decisions that improve their farm economics. Other provincial projects open up new businesses related to farming. In Perth County, Ontario, "Get out of Town" agri-tours bring city people to the country, raising the profile of farming and creating additional farm income.

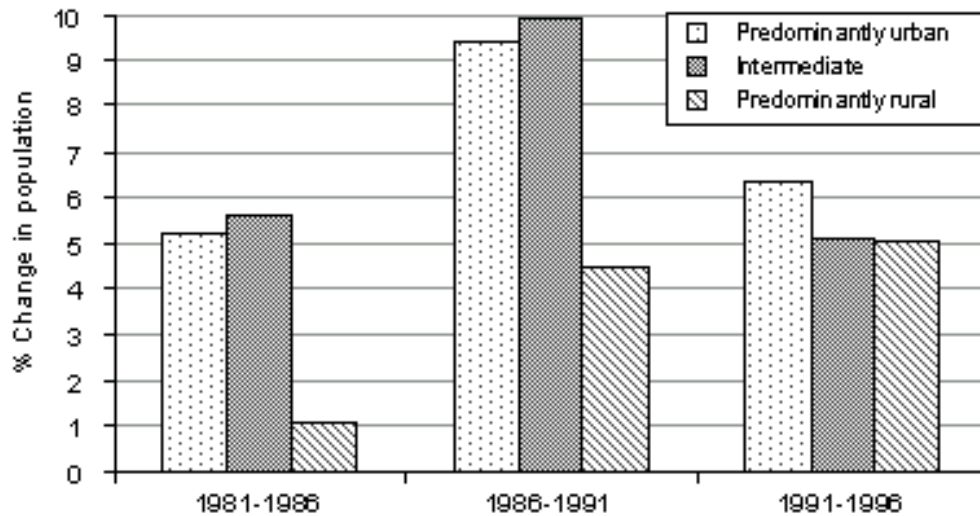
### **Distance Learning Project Spells Job Creation**

*In a distance learning project in Nelson, British Columbia, 30 people were trained in using the Internet to develop the expertise to start their own business. A business based in Edmonton, Alberta, read about this undertaking and recognized a business opportunity. In cooperation with Community Futures, Human Resources Development Canada, and the Canadian Rural Partnership, this private sector business has created a virtual call centre in Nelson to employ the people who received this training.*

### **Community Access Program**

*Fewer than 20 percent of Canadians have ready access to the Internet from their homes and offices. In rural areas, this share is much lower even though the Internet's capacity to promote social and economic development is particularly important to smaller communities. To address this issue, the Community Access Program was created in 1994 as part of the federal government's Connecting Canadians agenda. The program provides rural Canadian communities with affordable public access to the information highway and familiarizes rural Canadians with how this vehicle can be used for economic and community development, particularly job creation and growth.*

### Growth rate of Canada's rural population



Source: Statistics Canada

#### Community Futures Program

Many departments of the federal government have initiatives directed at rural development. In 1986, as part of Employment and Immigration Canada's Canadian Job Strategy, the Community Futures Program was introduced as a community economic development program to assist rural communities in developing strategies to deal with a changing economic environment. The program is based on the philosophy that local decision making and development are the most effective means for communities to shape their futures.

Administration of the program was transferred to Industry Canada and the federal Regional Development Agencies in 1995. The Community Futures Program supports Community Business Development Centres in Atlantic Canada and Community Futures Development Corporations in other parts of the country. These federally funded, nonprofit corporations, numbering 254 across Canada, are run locally by volunteer boards of directors and salaried staff. They have the job of

- delivering a range of services to small businesses, including counselling, referrals, provision of information on federal and provincial programs and services, assistance with business plans, and entrepreneurial training and development
- providing small business financing of up to \$125 000 on commercial terms through locally governed investment funds that offer loans, loan guarantees, or equity investments for business start-up, expansion, or stabilization to create or maintain jobs
- developing and implementing strategic plans for community economic development in cooperation with other partners.

Beyond farming, many provincial and territorial projects address rural development more broadly, building communities and bolstering rural businesses. For example, Community Enterprise is part of the British Columbia government's commitment to encourage greater economic diversification in coastal and rural resource-based communities. Using \$50 000 from Community Enterprise, the Columbia Shuswap Regional District of British Columbia is building its film and television industry, encouraging use of this location for filming and developing local systems and industry to support film production.

Sustainable rural development depends on recognizing the value of rural and remote communities to the future of Canada, acknowledging the differences in these communities and channeling a fair share of the country's resources to meet the needs of rural people. As for all sustainable development, sustainable rural development depends on proper attention being given to people (the social element), their enterprises (the economic element), and how they interact with the earth (the environmental element).

In most developing countries, promoting rural economic growth and social stability hinges largely on the concept of sustainable agriculture. In Canada, sustainable agriculture, though more critical in some regions than others, generally plays a much smaller role in securing the overall future of rural and remote peoples and communities. However, because it is the foundation of a safe and dependable food supply in Canada and contributes significantly to the Canadian economy, sustainable agriculture continues to be an important consideration in rural development.

# Sustainable Agriculture

## The Importance of Agriculture in Canada

First Nations were the first people to actively and successfully grow and harvest food crops in Canada, often transferring their knowledge and skills to European settlers. From this early agrarian culture, through the settlement of Canada's frontiers, to the world of agri-business today, agriculture has been a major force in developing this vast country and continues to be an important part of the national economy. Food is plentiful and of high quality in

### Aboriginal Agriculture in Manitoba

*The Tribal Wi-Chi-Way Capital Corporation and the First Nation Farm Credit (Manitoba) Corporation were awarded a grant of \$40 000 from the Manitoba Rural Adaptation Council to assess the current agricultural situation in First Nations communities and to identify key strengths, opportunities, and constraints that influence sustainable development and longer-term improvement in social, economic, and environmental conditions. Results of a survey of about 50 Aboriginal farmers were included in a preliminary report on this study. Of these farmers, 87 percent had nonagricultural work and 76 percent identified barriers to farming. The survey also showed that Aboriginal farms were smaller and had lower average receipts and less capital than farms in Manitoba's general operator community.*

### Canadian Rural Information Service

*Rural Canadians with questions about how to start a business or where to find child care or youth services can get information through the Canadian Rural Information Service. Designed to meet the need for many kinds of information, the service offers pathfinders on topics related to rural development, customized information packages on specific queries, a Web site of rural development resources, referrals to expert sources of information, customized bibliographic searches, and document delivery.*

### Canada's Action Plan for Food Security

Canada and available at a cost of about 11 percent of the average Canadian's income. In 1998, total farm market receipts were \$28 billion. The same year, total agricultural bulk exports were \$11.9 billion, contributing in an important way to Canada's positive international trade balance.

Agriculture's main goal is the production of food for people. Given the growth of the world's population today, this goal has come to mean food security — assuring a safe and dependable food supply for all individuals, peoples, and nations. *Canada's Action Plan for Food Security* highlights the importance of agriculture in many of its priorities.

*Canada's Action Plan for Food Security, prepared in response to the World Food Summit of 1996, has the following 10 priorities: the right to food, the reduction of poverty, promotion of access to safe and nutritious food, food safety, traditional food acquisition methods of Aboriginal and coastal communities, food production, emphasis on environmentally sustainable practices, fair trade, acknowledgement of peace as a precursor to food security, and a monitoring system for food security.*

## Working Toward Sustainable Agriculture

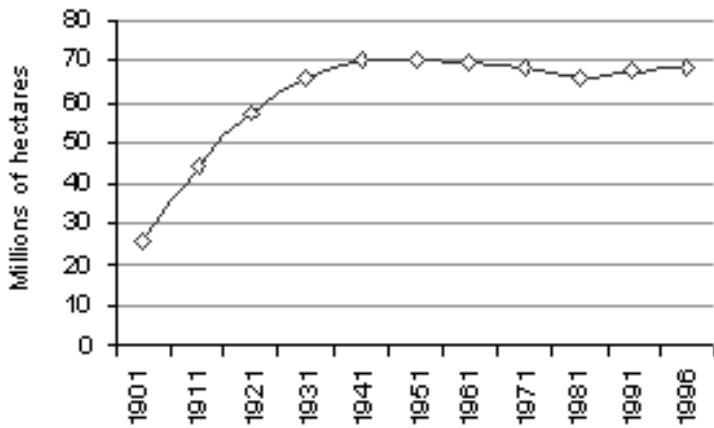
Canada is the second largest country in the world, but only 7 to 8 percent of its land base (about 68 million hectares) can be used for crop production. Only one-half of this area is considered prime agricultural land. During the past two decades, the total area of farmland (all land for crops, grazing and pasture, summerfallow, buildings and barnyards, bush, sloughs, marshes, etc., as defined by the Census of Agriculture) has remained relatively constant, while the area of cropland (land used to grow field crops, fruits, vegetables, nursery products, and sod) has increased. However, this seeming stability masks the continuing loss of prime farmland to urban development, which has encouraged the use of some environmentally sensitive lands for annual crop production.



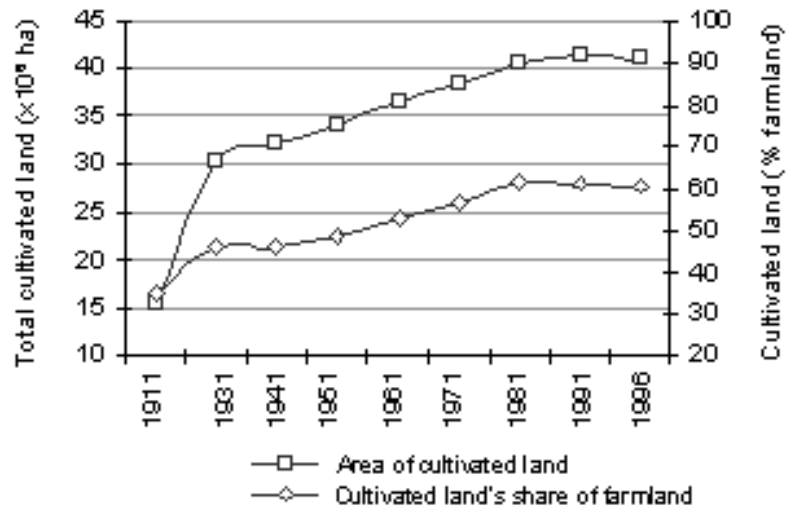
***Pioneering at Edenbridge (Jewish Settlement in Canada Series). William Kurelek. 19" x 22". 1975. Courtesy of the Estate of William Kurelek and The Isaacs Gallery, Toronto.***

With little prospect to develop new farmland, yet growing pressure to produce more food, it is essential that Canada carry out its agriculture sustainably. Taking an ecosystem approach to agriculture is the key to integrating the social, economic, and environmental components of sustainability. This process is a cooperative one, bringing together the knowledge, skills, and experience of governments, farm and environmental groups, farmers and farm suppliers, other rural residents, scientists, educators, and the interested public.

**Area of farmland in Canada**



**Cultivated land as a share of total farmland in Canada**



## ***The Role of Government***

### **The Federal Government**

The concept of agriculture's environmental sustainability in Canada dates back to the 1930s, when severe drought conditions in the western prairies led to the development of soil conservation programs. Since then, numerous conservation programs have been aimed at improving soil and water quality related to farming. Despite these efforts, the sector continues to face environmental challenges as it works with new technologies and responds to changing market pressures and growing societal concern about the environment. Policies of the 1990s broadened agriculture's environmental agenda, and one of the greatest successes of Canada's Green Plan in the early to mid-1990s was the agricultural

### **Saskatchewan Prairie Conservation**

programs carried out under agreements with the provinces to promote environmental sustainability in the sector.

In 1997 the federal agriculture department released its first sustainable development strategy and action plan for agriculture and agri-food production, built on four pillars: increasing understanding, promoting environmental and resource stewardship, developing innovations and solutions, and seizing market opportunities. Sustainable agriculture is also featured in the federal health department's sustainable development strategy, which commits Canada to developing and adopting sustainable pest management systems.

**Increasing understanding** aims at providing better information to improve the capacity of departmental and sectoral decision makers to integrate environmental factors into day-to-day decision making. Such information includes ecological and resource data (e.g., the Canadian Soil Information System and biodiversity inventories) and analytical information.

Performance measures are needed to assess the success in carrying out these strategies and in achieving the overall goal of environmentally sustainable agriculture in Canada. One type of performance measure is agri-environmental indicators, which estimate key environmental conditions, risks, and changes resulting from agriculture and assess management practices used by producers. The federal agriculture department has developed 14 agri-environmental indicators in six categories: environmental farm management, soil quality, water quality, greenhouse gas emissions, agroecosystem biodiversity, and production intensity. Among their many uses, these indicators shed light on the sector's environmental performance and its adoption of environmentally sound practices, and provide information to help develop agricultural policy and better target government programs.

**Promoting environmental and resource stewardship** encourages farmers and others in the sector to meet or exceed federal environmental regulations in their operations by using an environmental management system based on best management practices. Stewardship efforts already being made by the sector not only build an environmental ethic in the sector and help to demonstrate civic responsibility and improve public relations, they also open up marketing opportunities.

**Developing innovations and solutions** supports research, development, and technology transfer to address environmental challenges and foster sustainability in the agriculture and agri-food sector. The Government of Canada's primary interest is in carrying out research for the public good, generating technologies that are

## Action Plan

*Today, almost 93 percent of the Prairie ecozone is agricultural land. All that remains of its original native vegetation is about 1 percent of tall grass prairie, 19 percent of mixed grass prairie, and 16 percent of aspen parkland. In the late 1980s, the governments of Canada's three Prairie provinces and the World Wildlife Fund cooperated in developing the first Prairie Conservation Action Plan, a blueprint for conserving native prairie ecosystems in western Canada. To extend the benefits of this initiative, in 1997 Saskatchewan began its own Prairie Conservation Action Plan, building on the first plan and mirroring similar work in Alberta and Manitoba. The result of a partnership among 16 government and nongovernment agencies, the plan recognizes that conservation of native prairie can happen only if it is based on an ecosystem approach. The new plan, which addresses some special elements demanded by prairie society, land tenure, agricultural development, and fragmentation of native prairie, is being carried out with the involvement of private landowners and renters, rural and urban municipalities, the provincial and federal government, First Nations, and a host of interest groups.*

## Integrated Pest Management in British Columbia

*In the early 1900s, the codling moth was accidentally introduced to British Columbia, where it has caused untold damage to apple and pear crops. The Sterile Insect Release Program unites the efforts of governments, the tree fruit industry, fruit growers, and property owners in the province to deal with this pest problem. Each week during the growing season, 12 to 14 million sterile moths are released in 1700 commercial orchards in southern British Columbia. Sterile moths mate with fertile wild moths, but the resulting eggs do not*

effective, affordable, and readily available to farmers. It supports 18 agricultural research stations across the country, which often cooperate with provincial governments, universities, and the sector itself, allowing the costs and the results of research to be shared. In particular, cooperation and joint funding with industry help to stretch research funds and align government research priorities with the sector's real needs. They also speed up the process of transferring new technology out of the laboratories and into the hands of people who will use it, and help to raise the profile and acceptance of industry-generated technologies and products.

**Seizing market opportunities** equips Canada to compete well under globalization of markets and growing trade liberalization. Canada is working to

- increase the industry's awareness of environmental marketing and trade opportunities and constraints, and to enable it to respond quickly
- help demonstrate the environmental quality of products, practices, and services provided by the agriculture and agri-food sector
- influence domestic and international initiatives, such as multilateral agreements, in the interests of environmental progress and the Canadian industry.

*develop and the moth population drops.*

*Moths are reared at a \$7.4-million facility opened in 1993 near Osoyoos, British Columbia, and the \$3.4-million operating costs are shared by local growers and owners through taxes. In combination with other techniques, such as intensive monitoring, mating disruption, and the use of less-toxic pesticides, this program aims to reduce codling moth populations to levels for which chemical control is not needed.*

---

### Examples of sustainable agriculture initiatives across Canada

---

Province/Issue	Solution	Result
<b>British Columbia:</b> Control of soil erosion on intensively cropped fields during heavy winter rains.	Winter cover cropping between the rows of agricultural and horticultural crops, offering protective cover to the soil.	Winter cover cropping reduced soil loss by 78% for strawberries and 76% for grain corn. Cover crops turned into the soil also add organic matter and improve soil quality.

<p><b>Alberta:</b> Poor water quality in some streams and rivers, partly because of livestock access.</p>	<p>A project called "Cows and Fish", with the Alberta Cattle Commission, Trout Unlimited, and other partners. Ranchers apply grazing strategies such as access management and streambank revegetation to restore riparian health.</p>	<p>Water quality has improved and fish numbers have increased. Farmers and ranchers are now more aware of the importance of maintaining riparian health.</p>
<p><b>Saskatchewan:</b> High to severe wind erosion of cultivated land.</p>	<p>Reduced area in summerfallow and enhanced crop residue management through reduced tillage (e.g., direct seeding and chemical fallow).</p>	<p>Between 1981 and 1996, wind erosion risk dropped by 8% because of changes in cropping system, 25% because of changes in tillage practice, for a total reduction of 33%.</p>
<p><b>Manitoba:</b> Sustaining soil and water in the rural landscape.</p>	<p>Neighbourhood municipalities in Manitoba Conservation Districts working together as a watershed community to improve the rural environment.</p>	<p>In 1999, 8000 hectares of forages were seeded, 1300 kilometres of drains maintained, 56 kilometres of grassed waterways installed, 10 gullies repaired, 20 dams constructed, 120 wells sealed, 6 fisheries-enhancement projects completed, and 70 educational programs given in schools.</p>
<p><b>Ontario:</b> Need for holistic approach to environmental challenges on the farm.</p>	<p>Creation of the Environmental Farm Plan Program, with a workbook to help farmers assess their farms and then devise an action plan.</p>	<p>By April 1999, there were 16 000 participants; about 6000 of these received an environmental farm plan incentive of up to \$1500 to help correct an environmental problem on the farm, for a total program payout of about \$7 million so far.</p>

<b>Quebec:</b> Need of farmers for information on environmental farming practices.	Formation of farm conservation clubs, voluntary groups of 20 to 70 farmers with a shared interest in improving environmental management on their farms.	About 60 clubs have formed in the province, representing about 2300 farms; members direct the activities and benefit from the advice of an environmental advisor; members exchange information and keep abreast of new agri-environmental technologies and services.
<b>New Brunswick:</b> Disposal of unwanted pesticides and pesticide containers.	Operation Clean Sweep: farmers took unwanted pesticides to depots around the province every fall for 3 years or returned empty containers to the vendor.	Good participation of farmers; a change in attitude toward waste disposal; containers directed to a recycling facility.
<b>Nova Scotia:</b> Integration of sustainable agricultural resource management practices.	Formation of the Nova Scotia Environmental Farm Plan (EFP) program and revitalization of the Nova Scotia Soils Institute.	By 1999, more than 150 farmers had completed phase 1 of the EFP program; some had begun carrying out their plans. The Nova Scotia Soils Institute complements the EFP program by bringing resource users from various sectors (forestry, environment, farmers) together to coordinate rural soil and water management initiatives.
<b>Prince Edward Island:</b> Soil erosion on land under potato production.	Use of mulching, a new practice of spreading hay or straw on the field after potatoes are harvested.	As little as 2.3 tonnes of hay mulch per hectare can reduce soil loss by 75%. Soil loss was 3.1 tonnes under 2 tonnes of straw mulch per hectare and 1.8 tonnes under 4 tonnes of straw mulch per hectare.
<b>Newfoundland:</b> Poor soil drainage and low yields.	Installation of a series of perimeter interception ditches that follow the contours of the land.	System produces irregularly shaped fields, but crop yields improve considerably.

## **Provincial Governments**

Because of Canada's regional diversity in landscape, climate, and farm types, as well as the division of jurisdiction between federal and provincial/territorial governments, policies and programs to support sustainable agriculture are often designed most effectively in the regions. Provincial governments are usually in the best position to offer the practical support needed by farmers in moving toward sustainable agriculture, working in ways best suited to the farming needs of their regions. Successful technologies developed regionally can then be promoted nationally and applied in other settings where appropriate. For example, the agriculture ministries in British Columbia, Ontario, and Quebec have each produced a series of guides to best management practices to improve farm productivity and profitability, as well as environmental performance, in their provinces.

## **Government Controls and Policy**

Regulation has been the main government tool for protecting the environment. Federal laws such as the Canadian Environmental Protection Act, the Canadian Environmental Assessment Act, the Fisheries Act, the Canada Health Act, the Pest Control Products Act, the Plant Protection Act, and the Animal Protection Act contain provisions that are pertinent to the environmental performance of agriculture. New developments in biotechnology and other research and development tools are regulated to follow safety rules, and the Government of Canada supports science-based risk assessments for the products of biotechnology in order to protect the health of humans, animals, plants, and the environment.

Many provinces are in the process of issuing new regulations related to farming practice. In 1998, Quebec brought into force the Regulation for the Reduction of Pollution of Agricultural Origin to protect soil and water quality through provisions for the timing of manure application, the application of nutrients to phosphorus-rich soils, and the separation distances between watercourses and farm activities and structures. In Prince Edward Island, new legislation related to watercourse buffer zones will come into effect in 2000.

Municipal bylaws, usually designed to minimize conflict between neighbours, may limit the expansion of agriculture by controlling the siting of new operations, particularly intensive livestock operations. In some cases, environmental standards are developing faster than the ability of some farmers or commodity groups to adapt. Expansion of the Canadian hog industry is today most limited by the lack of cost-effective technologies and methods for land-based manure management needed to meet the requirements of environmental legislation.

In a shift toward nonregulatory measures to support environmental sustainability, governments are looking for new ways to encourage voluntary compliance and are offering information, technical assistance, and sometimes financial incentives to help farmers adopt conservation practices and avoid environmental damage. Canada is a strong proponent of developing policies that are targeted, transparent, and cost effective, and that do not distort production and trade.

## ***The Role of the Agriculture and Agri-Food Sector***

The agricultural industry has become increasingly aware of its environmental responsibilities in recent years. Commodity and farm groups are active throughout the country in developing ways to help farmers adopt more environmentally sustainable practices while maintaining productivity.

Codes of practice are guidelines that producers can follow to ensure that their management practices are environmentally sustainable. They are most effective when initiated by members of the industry itself with the assistance of scientists and other professionals. In some provinces, codes of practice are embedded in legislation. In British Columbia, for example, the Code of Agricultural Practice for Waste Management is part of the Agricultural Waste Control Regulation under the provincial Waste Management Act. Producers operating in compliance with the code are exempt from the act's requirement for a waste management permit.

In some provinces, peer advisory programs help farmers understand the concept of environmental sustainability and prevent penalties under environmental laws. If a nuisance or pollution complaint is directed against a farmer, a peer advisor (fellow farmer) visits the farm and suggests steps that the farmer can take to comply with pertinent guidelines, codes, or legislation. In this way, education is offered and the farmer is given the chance to comply voluntarily before regulatory agencies step in and order corrective measures.

Environmental farm plans are voluntarily prepared by farm families to identify their operations' environmental strengths and weaknesses and to set realistic goals to improve environmental conditions within the limits of time, equipment, and finances. They help to balance the economic and environmental goals of farming and encourage the adoption of best management practices that support these goals. Training, advice, and practical assistance are offered through various government programs and by industry groups. Environmental farm planning programs are administered in Ontario by the Ontario Soil and Crop Improvement Association and the Ontario Ministry of Agriculture, Food and Rural Affairs. In the Atlantic provinces, programming was initiated and coordinated by the Atlantic Farmers Council, with technical assistance from the Eastern Canada Soil and Water Conservation Centre. It is now administered by provincial farm organizations.

Environmental certification, based on a monitoring system to

### **Code of Practice for Environmentally Sound Hog Production in Canada**

*Canada's hog industry is poised to expand as international markets for its products continue to grow. However, a growing number of applications for new or expanded sites are being rejected or held up for long periods at the municipal level because of environmental concerns. To assist hog farmers in dealing with these concerns, the Canadian Pork Council has developed a code of practice in partnership with Agriculture and Agri-Food Canada, Environment Canada, provincial governments, universities, and lending institutions. Following the code is strictly voluntary, and compliance with federal and provincial regulations is still required. This cooperation between industry and government has set the stage for the new Livestock Environmental Initiative under the Canadian Adaptation and Rural Development Fund, which will devote \$2 million to livestock research and technology development, and \$300 000 to developing an environmental certification system for the hog industry.*

ensure adherence to environmental standards, appears to be a logical step for environmental programming in the next decade. Industry and governments are working together on certification options, usually using a domestic standards process or applying the International Standards Organization's ISO 14000 to farm enterprises.

## ***The Role of the Community***

After a decade of effort, programs such as Canada's Green Plan have shown that tangible improvements in the quality of the environment are usually the result of community effort. The most sophisticated prediction models, competent extension staff, and programs for financial assistance cannot improve environmental quality as it relates to agricultural practice without the commitment of individual farmers, ranchers, and other community residents.

The community approach has been particularly appropriate in dealing with issues of water quality. Before they can deal with the issue, the concerned community must agree on the need for intervention. The form this intervention takes depends on the value the local community places on the environment and the protection of various water uses. Building awareness of the issues among the potential partners is an essential first step in establishing a watershed management group. The effectiveness of this first action is enhanced if leadership is taken by farmers and other land users. The diversity of interests, responsibilities, and expertise needed for this type of project requires the creation of a coalition at the scale of the target area, including municipalities, private and public agricultural and environmental consulting services, local representatives of governmental organizations, interest groups and private organizations, community groups, and farmers and ranchers.

## ***International Cooperation***

At the same time that trade is being globalized, there is growing international concern about the sustainability of this development, particularly environmental sustainability. This past decade has seen a proliferation of international environmental agreements to which Canada has become party, many of which are mentioned in a later section of this monograph on the state of agricultural resources.

In the developing world, where much of the population is still

## **Community Action to Restore the Boyer River in Quebec**

*The Boyer River, located near Quebec City, on the south shore of the St. Lawrence River, drains a watershed of 21 700 hectares, much of it farmland under intensive livestock production. After years of industrial, municipal, and agricultural pollution, the river is so full of nutrients and suspended sediment that the smelt fishery has collapsed and swimmers go elsewhere. Restoring the river's water quality needed the involvement of the entire watershed population. A committee of representatives from farmer groups, municipalities, and the provincial ministries of agriculture and environment organized public information meetings and training sessions. Farmers have received help to build appropriate manure storages, stabilize river banks, manage animal watering places, and restrict animal access to the river. They have also worked with an expert to develop best management practices. This project has created a feeling of identity, membership, and cooperation among people within the watershed.*

## **Sustainable Agriculture in China**

*Through the Canadian International Development Agency (CIDA), Canada funds the international secretariat of the China Council for International Cooperation on Environment and Development (CCICED). The CCICED advises the State Council and Premier of China on policy options for sustainable development in China. Its Sustainable*

rurally based, agriculture is still a main engine for economic growth and rural prosperity. The Government of Canada believes that people of all countries should have access to adequate food of sufficient quality for a healthy life, and works through two public agencies to promote appropriate conditions for food security in developing countries. Sustainable agriculture is a basis for achieving this.

The Canadian International Development Agency (CIDA) continues to view agricultural and rural development as a creative and efficient means of meeting its priority goals, working in partnership with many countries and groups. In the Pan-African Bean Research Alliance, CIDA has collaborated with the International Centre for Tropical Agriculture to work with large numbers of poor women farmers to improve the production of beans, the major source of protein and an important source of cash income for millions of African families. The Farm to Market Entrepreneur Development Project in Bangladesh directly involves farmers and builds on the growing interest on the part of nongovernment organizations and commercial enterprises to provide goods and services to the agricultural sector. Agricultural Governance Support to Mali, a multidonor initiative, has resulted in the transition of state-controlled cereal markets to a more open-market situation, resulting in increased production and cereal self-sufficiency.

The International Development Research Centre (IDRC) initiates, encourages, supports, and conducts research into the problems of the developing regions of the world. Several of its priorities touch directly on sustainable agriculture and rural development: food security, equity in natural resources use, biodiversity conservation, and sustainable employment. In its early days, IDRC's strengths in agriculture, food, and nutrition science led it to fund hundreds of projects conducted by researchers in developing countries into their own problems related to sustainable agriculture and rural development. After the 1992 Earth Summit, the centre reoriented its programming to promote sustainable development, particularly community-based natural resource management tailored to the different conditions in Africa, Asia, and Latin America. It has also developed a closely related program on the sustainable use of biodiversity. For example, the Nagaland Environment Protection and Economic Development Project, a partnership between IDRC and the Government of Nagaland, India, develops practical approaches to transforming the existing practice of shifting cultivation into more sustainable practices, such as agroforestry.

*Agriculture Working Group recommends agricultural projects, especially related to cropland and grassland management. For example, Canada (CIDA) and the Government of the Inner Mongolia Autonomous Region are jointly funding a 5-year project to test and demonstrate sustainable cultivated and grassland technologies from western Canada at four sites in Mongolia. Agriculture and Agri-Food Canada will carry out the project, working with the Vocational and Technical College of the Inner Mongolia Agricultural University. The project will involve close cooperation with an existing World Bank project on poverty alleviation and a CIDA dairy project.*

CIDA and IDRC have collaborated in joint ventures, particularly those with a strong research component. The Andean Farming Systems Project in Peru supported on-farm research for improved crop and livestock production under marginal high-altitude conditions. Both agencies are founding members of the Consultative Group for International Agricultural Research (CGIAR) and continue to stress the importance of international cooperation in science-based agricultural development. This focus has given birth to the Canada–CGIAR Network Initiative, which seeks to build a consortium of Canadian organizations and individuals who share a concern for poverty, food insecurity, and natural resource degradation in developing countries.

Through promotion of the tenets of sustainable development in its participation in international organizations such as the Food and Agriculture Organization of the United Nations and the Inter-American Institute for Cooperation on Agriculture, Canada is viewed around the world as an open and capable partner in addressing the many problems that face all nations in balancing the environmental, economic, and social pillars of sustainable agriculture and rural development.

## The State of Resources Affected by Agriculture

As agricultural production in Canada has intensified in recent decades, significant pressures have been exerted on the environment. Much research has been done by governments, universities, and scientific organizations to track the environmental performance of agriculture.

### **Soil Quality**

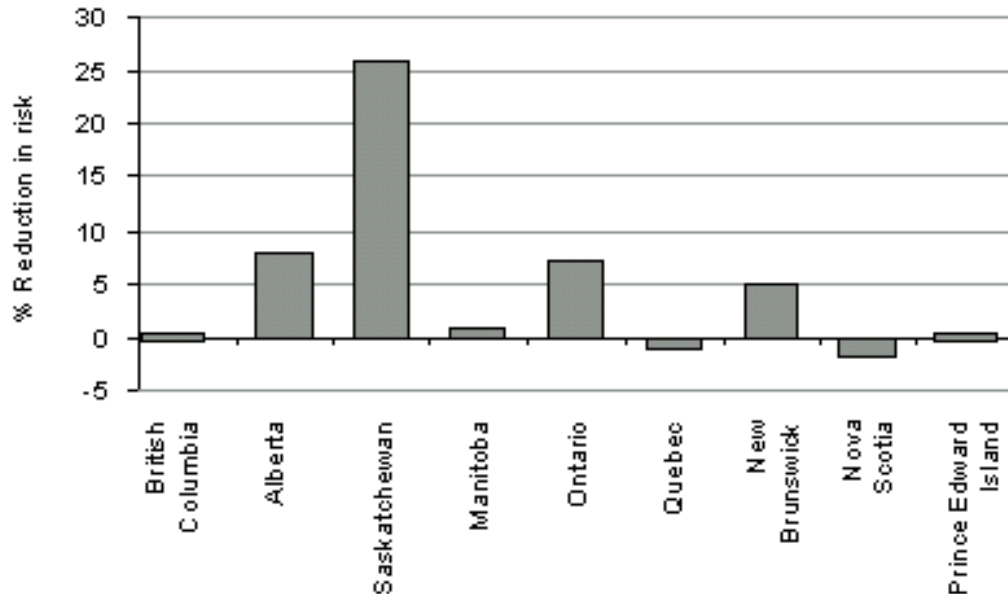
As a result of soil conservation programs and the development and adoption of conservation farming technologies, there are signs that the quality of Canada's agricultural soils is improving in some areas to some degree. Indicators show that cropping measures and greater use of conservation tillage contributed to a drop in the risk of soil erosion by water in the Prairies, Ontario, and New Brunswick between 1981 and 1996. Technologies for reduced tillage combined with a reduction in the area of summerfallow also led to a 30 percent drop in the risk of wind erosion on the Prairies over this same period. The risk of tillage erosion — the displacement of soil by tillage implements — dropped by 9 to 26 percent throughout the country during this time. When soil is covered by the crop canopy or crop residues, it is less vulnerable to erosion. An indicator of soil cover that includes a measure of residue cover shows that the number of days that soil was left bare

### **Controlling Water Erosion of Soil on Potato Land in the Maritimes**

*Land under potato production in the Maritimes is particularly vulnerable to soil erosion by water because row crops like potatoes leave much of the soil's surface exposed to the elements for long periods. Other factors contributing to soil erosion on these lands include high rainfall, light-textured soils, and cultivation on long, steep slopes. A wide range of conservation practices is needed to control the severe water erosion on Maritime potato lands. The most common methods are cross-slope cultivation, terracing, grassed waterways, and surface water inlets. Other complementary methods include strip cropping, conservation tillage and residue management, cover cropping, and mulching. In a comparison of two New Brunswick potato fields, Agriculture and Agri-Food Canada researchers found that the field with up- and down-slope cultivation and no erosion controls lost about 10 to 100 times more soil than the field with diversions and grassed waterways.*

dropped by 20 percent on Canadian cropland between 1981 and 1996, a positive trend.

### Reduction in the area of Canadian cropland at risk of a tolerable level of water erosion between 1981 and 1996



An indicator of the risk of soil compaction shows that the area of compacted soils under crops that alleviate compaction decreased by 11 to 21 percent in Ontario and the Maritimes between 1981 and 1996. The indicator also shows that the area of soil that was both susceptible to compaction and under compaction-inducing crops increased by about 50 percent or more in Ontario, Nova Scotia, and Prince Edward Island during this time.

Over the years of farming, organic matter is lost from the soil unless steps are taken to protect it and build it up, such as by preventing erosion, maintaining soil fertility by adding nutrients, and adding organic matter such as animal and green manure and compost. A computer-modelled indicator shows that most agricultural soils in Canada continue to lose carbon every year, but at a slower and slower rate because of the adoption of soil conservation measures. The indicator estimates that farm soils in Saskatchewan, where reduced tillage and no-till have been adopted by many farmers, are already accumulating carbon. On the whole, Canadian agricultural soils are predicted to begin accumulating carbon in 2000, reaching a limit 20 years later. This accumulation, called carbon sequestration, may prove to be an

#### Reducing Soil Compaction under Reduced Tillage in Ontario

*Corn producers in southern Ontario often cite soil compaction as the leading problem for soil and water conservation on their farms. Soil compaction occurs naturally, but it can also be caused by wheel traffic on the field and by tillage, especially when soils are still wet. In reduced tillage systems, soil compaction must be alleviated without reducing the amount of protective cover by crop residues or incurring large tillage costs. To achieve this, University of Guelph and Agriculture and Agri-Food Canada researchers are examining systems that*

important component of reducing atmospheric levels of carbon dioxide, a greenhouse gas.

Moderate to severe soil salinity reduces annual yields of most cereal and oilseed crops by about 50 percent. An indicator that assesses the risk of soil salinization under dryland agriculture in the Prairies shows that about 60 percent of prairie cropland was at low risk of soil salinization in 1996. About 3 percent of cropland shifted from the high to moderate risk class between 1981 and 1996, probably because of changes in agricultural practice, including adoption of conservation tillage and reduction of area under summerfallow.

*perform tillage in narrow strips to assess the impact of in-row soil loosening on corn performance. Another option being explored is combining fertilizer placement with the strip tillage operation.*

## **Water Issues**

The agricultural uses of water are many, including growing crops, watering livestock, cleaning farm buildings and implements, and using it in the home. It is safe to say that without an adequate supply of water of sufficient quality, the economies and ecosystems of the rural landscape would decline and eventually cease to function.

## **Water Quality**

A general decline in the risk of soil erosion by water and wind implies a decline in the sedimentation of watercourses and water bodies by farm soil. If sedimentation continues to decrease, so too will the risk of water contamination by substances carried by soil particles, such as phosphorus, some pesticides, and bacteria. However, sediment contamination continues to be a serious water quality problem at some times of the year in many regions, especially in the Maritime provinces, where wide-row crops are grown on rolling land with soils susceptible to erosion.

Nitrate from mineral fertilizer and animal manure is present in nearly all groundwater underlying the main agricultural regions of Canada. Nitrate levels in groundwater supplies are generally below the Canadian guideline for drinking water quality, but in some areas of intensive agriculture they exceed the guideline. Under prevailing management practices, residual nitrogen is accumulating in many agricultural soils under intensive production, such as the Lower Fraser Valley in British Columbia and the Great Lakes–St. Lawrence Lowlands in Ontario and Quebec, increasing the risk of groundwater contamination by

### **Nitrate Contamination of the Abbotsford–Sumas Aquifer in British Columbia**

*The Abbotsford–Sumas aquifer straddles the border between British Columbia and the state of Washington. Groundwater nitrate concentrations exceed the Canadian guideline for drinking water quality of 10 milligrams of nitrate per litre (mg/L) in a large portion of the aquifer, and concentrations in individual wells have been as high as 40 mg/L. Agriculture has been one of the main contributors to nitrate contamination of the aquifer. Over the past 30 years, an increase in poultry operations (which do*

nitrogen in these areas. In some areas of the Prairies, there is an accumulation of nitrate under the root zone that may move into groundwater if leaching conditions occur.

Some pesticides are commonly detected in both the groundwater and surface waters in Canada's agricultural regions, but generally at concentrations well below the Canadian guideline for drinking water quality. In keeping with the United Nations Economic Commission for Europe's Protocol on Persistent Organic Pollutants (POPs), most pesticides that are POPs have generally been banned from Canadian agriculture. The few remaining uses of the pesticide lindane are under review for their continued acceptability. Contamination by such pesticides in Canada is steadily declining, except where they are deposited by atmospheric transport from countries where they are still used.

Bacterial contamination of well water is widespread and usually results from faulty well construction. Contamination of surface waters is sometimes associated with leaking manure storage systems or inappropriate application of manure to farmland. Evidence is lacking to link heavy metal contamination of water to agricultural activity.

*not have a large enough land base for manure application) and an increase in the production of raspberries (a crop with a low nitrogen requirement and to which manure is applied) have resulted in the application of excessive amounts of manure, and thus of nitrogen, to the limited land base. This in turn has led to nitrate contamination of the aquifer. Steps are now being taken by farmers to manage nutrients more carefully and to transport manure to other locales with lower animal populations.*

### **Risk of water contamination by nitrogen on farmland in Canada's humid regions under prevailing management practices in 1996**

<b>Province</b>	<b>Farmland area* (million ha)</b>	<b>Share (%) of farmland in various water contamination risk classes</b>		
		<b>Low (0-6 mg N/L)</b>	<b>Intermediate (6.1-14 mg N/L)</b>	<b>High (&gt;14 mg N/L)</b>
British Columbia	0.1	6	25	69
Ontario	4.2	39	44	17
Quebec	1.9	58	35	6
Atlantic provinces	0.4	82	15	3

\*Farmland area here is the sum of all Census of Agriculture land classes except All Other Land. Value for British Columbia is for the south coastal region only.

## Water Quantity

Agriculture competes with many other uses of freshwater in Canada, including thermal power generation, manufacturing, municipal uses, fisheries, wildlife habitat, and human recreation. On a national level, agriculture withdraws a relatively small amount of water (8 percent) compared to thermal power generation (60 percent) and manufacturing (19 percent). However, agriculture consumes a large portion of what it uses, returning less than 30 percent to its source where it can be used again. About 75 percent of all agricultural withdrawals of water occur in the semi-arid Prairies. Generally the provinces have jurisdiction over their waters, but federal legislation governs some aspects of water development and use. Water rights legislation has been developed to regulate the withdrawal of surface water and groundwater for beneficial purposes.

At the same time that agricultural demand for water is growing, particularly for irrigation, other sectors are demanding more too. Competition for the finite supply of water, particularly in water-short areas of the country such as the Prairies and the interior of British Columbia, has already given rise to conflict among users. This situation becomes worse during the droughts that periodically occur in parts of Canada. In agricultural terms, the moisture deficit caused by drought places farmland soils at risk and poses a threat to both crop and livestock production. At least 40 severe droughts have affected western Canada in the past 200 years. Droughts also occur in eastern Canada, but they are usually shorter, smaller in area, less frequent, and less severe. Drought is still a poorly understood phenomenon. Continuing research is needed to improve the capability to analyze (particularly with regard to probability and extreme statistics) and predict drought. The federal agriculture department works with other federal and provincial agencies to monitor the probability of severe, widespread drought in the Prairies and to develop long-range climate forecasts for this region. It is also involved in many water conservation and development projects, as well as activities to support preventative and preparatory water systems and other drought responses.

Global warming scenarios indicate that drought will be more frequent and severe where precipitation does not make up for the increased water losses from evaporation. However, the uncertainty in climate models, particularly related to precipitation, makes it difficult to predict confidently where, when, and to what degree droughts will take place in the future. Climate change models usually predict increased precipitation in most areas of Canada. However, water may also become less available in some areas

### Demand Management to Conserve Irrigation Water in British Columbia

*In the summer, an average of 123 million litres of water is consumed each day in the South East Kelowna Irrigation District in the Okanagan Valley, British Columbia. Ninety-five percent of this water is used in agriculture to irrigate about 2500 hectares of land. About 1400 domestic connections account for the remainder. In 1995, this district cooperated with the British Columbia Ministry of Agriculture and Food to run a pilot project aimed at reducing water use through universal metering and irrigation scheduling. Ten growers participating in the project use measurements of soil water and climate data to schedule their irrigation. Monitoring actual soil moisture allows these farmers to apply irrigation water only as needed, resulting in more efficient water use. Since solid set and handline sprinklers are the main irrigation systems used throughout the district, additional water savings may be realized by converting from sprinklers to more efficient drip or micro-spray irrigation.*



Photo credit: Ontario Soil and Crop Improvement Association.

because higher air temperatures, longer ice- and frost-free seasons, and longer growing seasons are expected to contribute to greater evaporation and transpiration and more loss of water to the atmosphere. If the significant declines in streamflow, groundwater levels, and lake levels suggested by climate change scenarios are realized, there will be greater potential for competition for water and conflict over water allocation. This competition could be felt between consumptive and nonconsumptive users (including fish and wildlife), upstream and downstream users, rural and urban areas, and arid and non-arid regions, as well as across political boundaries.

## **Watersheds and Aquatic Ecosystems**

Situated as it is within watersheds, agriculture often interfaces with watershed components and always has some effect. Agricultural and other rural development activities often lead to land clearing, drainage, and straightening of channels, which can alter the physical nature of waterways. Although irrigation drains often provide new aquatic habitat, many physical alterations alter habitat negatively and affect its ability to support a diverse biological community. Freshwater and marine aquatic habitats are also affected by declining water quality, the result of nutrient and pesticide runoff from farmland. Excess nutrients in surface waters cause eutrophication and oxygen depletion, impairing living conditions for some species. The quality of aquacultural species may be compromised under these conditions, posing a risk to this growing industry in Canada. Nitrogen and some pesticides may also be directly lethal or sublethal to aquatic organisms when concentrations become high enough.

Numerous conservation projects have been undertaken on Canadian farmland to restore and improve riparian and aquatic habitat. Some poorly drained marginal farmlands are being retired and returned to wetlands, and the physical condition and water quality of streams and agricultural drains are being restored to create usable fish and wildlife habitat. Enhancement measures not only benefit fish and wildlife, but in many cases improve the quality of water used on the farm.

## ***Air Issues***

Atmospheric concentrations of greenhouse gases — particularly

### **Rehabilitating Mink Creek in Manitoba**

*Mink Creek is one of the tributary streams draining into Dauphin Lake, Manitoba. Until 1950, the lake supported a large commercial and sport walleye fishery, but fish harvests then dropped by 90 to 95 percent. A major cause of the decline was extensive channelization of the tributary streams to improve agricultural drainage and reduce spring flooding. Rehabilitation of the creek began in 1985 and involved the construction of a series of pools and riffles in three segments of the channelized stream. The success of walleye spawning was then followed for six years. Egg scour and egg drift were*

nitrous oxide, methane, and carbon dioxide — have been increasing dramatically in the past 20 years, enhancing the greenhouse effect by which the earth's atmosphere is warmed. Uncontrolled buildup of these gases in the atmosphere may cause global warming and other changes in climate. According to the most recent estimates, total agricultural emissions of nitrous oxide, methane, and carbon dioxide (the first two expressed in carbon dioxide equivalents) in 1981, 1986, 1991, and 1996 were 61, 56, 57, and 62 megatonnes, respectively, representing about 10 percent of total 1996 Canadian emissions. These amounts include all sources associated with farming except food processing and transportation, and reflect an increase of about 4 percent between 1981 and 1996.

Agricultural emissions of nitrous oxide rose by 21 percent between 1981 and 1996, from 99 to 120 kilotonnes, mainly as a result of more intensive farming practices and growing use of nitrogen fertilizer. Methane emissions remained relatively constant, and carbon dioxide emissions dropped by 13 percent, from 30 to 26 megatonnes. Under the United Nations Framework Convention on Climate Change and its Protocols, Canada is developing a national response strategy, with possible limitations on agricultural emissions of greenhouse gases and possible enhancements of agricultural sinks of greenhouse gases.

Methyl bromide, a broad-spectrum fumigant used in the Canadian agriculture and agri-food industry to control pests and diseases in soil, facilities, and commodities, has been listed as an ozone-depleting substance under The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. Along with other developed countries that are signatory to the Montreal Protocol, Canada must completely phase out the consumption of methyl bromide by 2005. Cooperative research and demonstration projects between government and industry have already reduced the use of methyl bromide in Canada by about 40 percent. Some alternatives to methyl bromide have been identified, including different chemicals and methods. For example, a guideline has been prepared to encourage the use of integrated pest management, combining preventative and treatment practices, to control pest problems in food-processing facilities.

Agricultural emissions of ammonia and particulate matter are being linked to various environmental effects, such as acidification, eutrophication, and smog. About 80 percent of ammonia emissions from Canadian farms come from animal manure; most of the rest is released from applied fertilizer. Agriculture is thought to be a significant source of airborne particles, or particulate matter, in rural areas. Coarser, primary

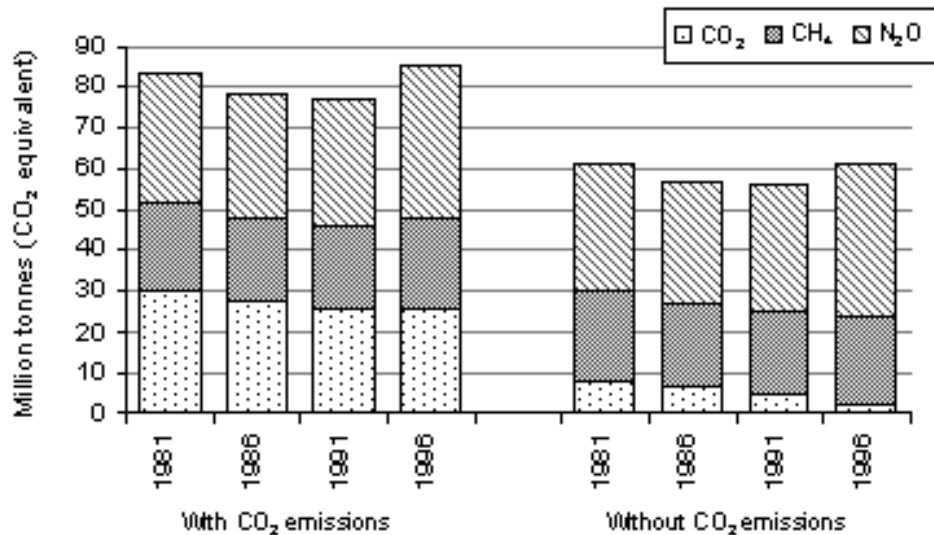
*considered a serious problem, as viable eggs could settle and die in high siltation areas near Dauphin Lake. Relative to egg densities, egg drift was 1.5 times greater from the channelized section compared to the rehabilitated section, which appeared to trap and retain eggs that entered from the upstream channelized reach.*

### **Alternatives to Methyl Bromide in Ship Holds**

*The Canadian Industry/Government Working Group on Methyl Bromide Alternatives examined alternatives to the current method of methyl bromide fumigation of empty ship holds, often used to transport agricultural commodities such as grain. Vials containing adults and eggs of a variety of insect pests were placed in each of three ship holds. The insects were then subjected to methyl bromide fumigation followed by recapture of the methyl bromide, fumigation by phosphine from cylinders, or controlled generation of phosphine. Results showed that all three methods can be used to limit methyl bromide emissions during ship hold fumigations. Both phosphine treatments killed 100 percent of the eggs and adult insects within 72 hours. The methyl bromide recapture technique captured about 85 percent of the methyl bromide used. The advantages of this method include re-use of the captured methyl bromide and reduced risk to human health in the vicinity of the fumigation site.*

particles come from the dust released during land tillage and wind erosion of soil. Dust from agricultural lands can be reduced by growing shelterbelts, maintaining soil cover, and minimizing tillage. Agricultural ammonia is also a precursor of smaller, secondary particulate matter. Ammonia emissions can be reduced by appropriate manure handling and storage, animal feed composition, and fertilizer application.

**Greenhouse gas emissions from Canadian agroecosystems, with and without carbon dioxide emissions from on-farm fossil fuel use and indirect sources**



## Agroecosystem Biodiversity

Recognizing that the earth's biodiversity is a resource needing conservation, Canada joined with many other nations in signing the Convention on Biological Diversity in 1992. Under the convention, Canada's federal, provincial, and territorial governments worked together to develop the Canadian Biodiversity Strategy, released in 1995, which includes many agricultural objectives. Agriculture benefits from biodiversity in many ways, but it has also reduced biodiversity over the years, mainly through the conversion of natural habitats, but also through effects on soil and water quality and the loss of old varieties of plants and domestic animals.

To remedy this situation, many projects are under way on Canadian farmland to conserve and restore wetlands and riparian habitat; to protect endangered wild species (such as the swift fox

### The North American Waterfowl Management Plan

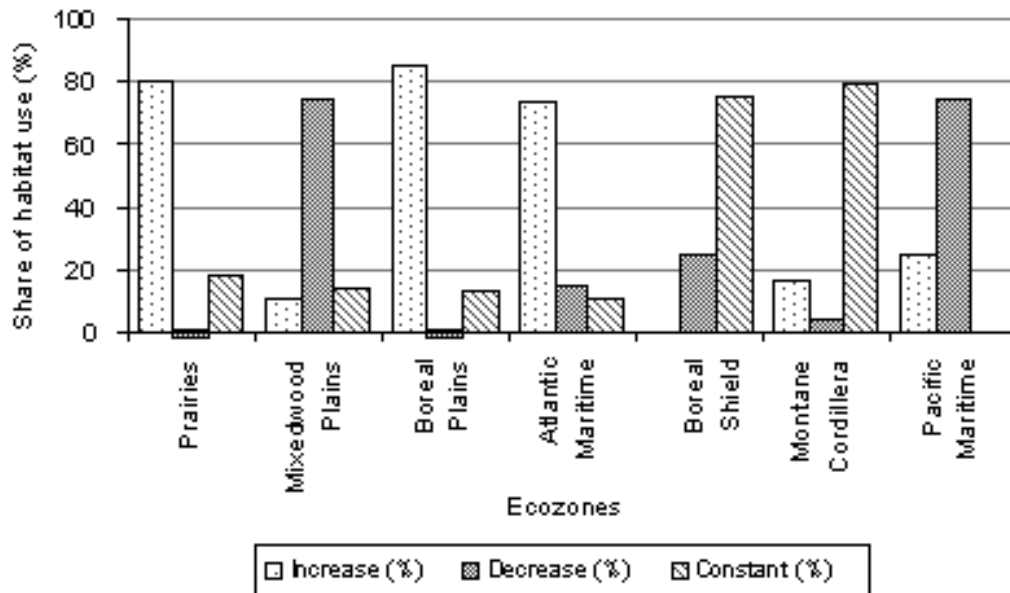
*Canada and the United States (1986) and later Mexico (1994) signed the North American Waterfowl Management Plan to restore declining waterfowl populations in North America to 1970s levels. In Canada, the plan focuses on conserving and restoring wetland and upland habitats for waterfowl, particularly in the Prairies, which provide breeding habitat for almost 40 percent of the continent's duck population. A landscape approach is*

and the wood poppy) and to support species recovery; to conserve endangered domestic livestock breeds and plant varieties; and to improve soil and water quality as they are affected by agriculture. These activities are helping to meet two of the agricultural goals of the Canadian Biodiversity Strategy — to maintain the agricultural resource base and to promote sustainable farming practices that are compatible with wildlife.

An indicator of the availability of wildlife habitat on farmland shows a positive or neutral trend in all ecozones in which agriculture is practised except the Pacific Maritime (in British Columbia) and Mixedwood Plains (in Ontario and Quebec), mainly as a result of the intensity of agriculture in these areas. The Government of Canada has committed to introducing legislation aimed at recovering species at risk, accompanied by funding for stewardship programming. Studies have shown that agricultural land provides habitat for more than 80 percent of species known to be at risk in Canada, making the participation of farmers and ranchers in stewardship programs essential to the conservation of important wildlife habitats (e.g., wetlands and woodlands).

*taken and agreements are made with farmers and other landowners to modify their land use and land management practices for the benefit of both their operations and wildlife. Ten years into the program, dabbling duck populations had nearly reached the 1970s average, though much work remained for other species. Landowners and the general public are positive about wetland and waterfowl conservation, and communities benefit through jobs and greater tourism opportunities associated with the plan. The plan is now being broadened to include other migratory bird initiatives, expand partnerships, strengthen science, and work at a broader landscape level.*

**Share of habitat-use units for which agricultural habitat area in Canada increased, decreased, or remained constant between 1981 and 1996**



Note: A habitat-use unit is a single use of a habitat by a wildlife species, such as mallard feeding, mallard loafing, or mallard nesting.

## ***Production Intensity***

The concept of eco-efficiency can be applied to agriculture to produce more-valuable goods and services using fewer materials and energy inputs, in turn minimizing losses to the environment and reducing pollution. Agriculture uses many inputs in the production process, including capital, labour, machinery, land, water, nutrients, pesticides, and energy. Because inputs are priced in the marketplace, there is some incentive to use them efficiently.

An indicator estimating residual nitrogen (nitrogen left in the soil after the crop is harvested) shows a strong trend of increasing levels in all provinces except British Columbia between 1981 and 1996. In humid areas of the country, this trend may be associated with declining water quality resulting from nitrogen contamination. Another indicator shows that energy input into Canada's primary agricultural production grew by 8 percent during this period, while total energy output (e.g., energy held in agricultural products) grew by 13 percent, mainly a reflection of the situation in the Prairies, which make up most of Canadian farmland.

## **NEXT STEPS**

Despite considerable progress toward rural development and sustainable agriculture in Canada, much more work is needed. The following items are priorities for this work.

### Rural Development

- continued dialogue with the residents of rural and remote communities to keep in touch with their interests and needs
- development of a Federal Rural Action Plan putting in place actions responding to the 11 priority areas under the Federal Framework for Action in Rural Canada
- enhanced opportunities for youth to obtain education and training and find long-term employment in rural regions.

### Sustainable Agriculture

- assessment of the effectiveness of the federal agriculture department's first sustainable development strategy and the drafting of a second strategy, as well as that of other federal strategies related to sustainable agriculture
- a resolution of the tension between intensive farming (of both crops and livestock) and environmentally sustainable agriculture
- continued support of the national agri-environmental indicator project and provincial monitoring projects that regularly assess the state of agricultural resources
- field research to test the findings of indicator programs and identify areas to which programs can be targeted
- greater emphasis on developing effective programs with adequate funding to improve manure management and improve relations between farmers and their neighbours
- further development and adoption of integrated pest management

- continued research in biotechnology, with adequate risk assessments
- research into tillage alternatives where reduced tillage and no-till are not an option
- continued support for environmental farm planning, including a nutrient management component based on adequate soil and crop testing and a good knowledge of the nutrient content of various inputs such as manure
- support for the certification process for organic products and enhanced research on organic agriculture and food products
- further research on agricultural practices to reduce greenhouse gas emissions, and encouragement of farmers to adopt these practices
- attention to other emerging air quality issues, such as those related to particulate matter and ammonia
- research on, and adoption of, demand management methods to promote water use efficiency, particularly related to irrigation technology
- water rights reform and fair resolution of conflicts over water use
- development of effective ways to improve the environmental image of farming and to capitalize on this image for marketing.

## Conclusion

Cultivating a secure future in Canada involves careful attention to rural development, including sustainable agriculture. Progress in these areas must be set in the context of federal–provincial agreements and budgetary constraints, international debates and instruments, and, perhaps most important, the will of Canadians to make changes and adopt the ethics that sustainability requires. Many Canadians have expressed in practical ways the desire to live and carry out their businesses in a sustainable way. It remains for governments to provide continued support for these endeavours and to encourage a wider adoption of the principles and practices of sustainable development in both agriculture and the broader rural community in Canada.

## SELECTED READINGS

Acton, D.F., and L.J. Gregorich (eds.). 1995. *The Health of Our Soils: Toward Sustainable Agriculture in Canada*. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at [http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/\\_overview.html](http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/_overview.html)

Agriculture and Agri-Food Canada. *Canadian Fertilizer Consumption, Shipments and Trade*. Agriculture and Agri-Food Canada, Policy Branch, Ottawa. Published annually. Available on the Internet at <http://www.agr.ca>

———. 1994. *Trade and Environment: The Agriculture Dimension*. Discussion Paper. Agriculture and Agri-Food Canada, Environment Bureau, Ottawa.

———. 1997. *Agriculture in Harmony with Nature: Strategy for Environmentally Sustainable Agriculture and Agri-Food Development in Canada*. Agriculture and Agri-Food Canada, Environment Bureau, Policy Branch, Ottawa. Available on the Internet at [http://www.agr.ca/policy/envharmon/docs/strat\\_e.pdf](http://www.agr.ca/policy/envharmon/docs/strat_e.pdf)

———. 1997. *Biodiversity in Agriculture: Agriculture and Agri-Food Canada's Action Plan*. Agriculture and Agri-Food Canada, Environment Bureau, Ottawa. Available on the Internet at [http://www.agr.ca/policy/environment/publications/biodiversity/action\\_plan.pdf](http://www.agr.ca/policy/environment/publications/biodiversity/action_plan.pdf)

———. 1997. *Profile of Production Trends and Environmental Issues in Canada's Agriculture and Agri-Food Sector*. Agriculture and Agri-Food Canada, Environment Bureau, Policy Branch, Ottawa. Available on the Internet at [http://www.agr.ca/policy/envharmon/docs/profil\\_e.pdf](http://www.agr.ca/policy/envharmon/docs/profil_e.pdf)

———. 1998. *Challenges and Implications Arising from the Achievement of CAMC's 2005 Agri-Food Export Target*. Agriculture and Agri-Food Canada, Economic and Policy Analysis Directorate, Policy Branch, Ottawa. Available on the Internet at <http://www.agr.ca/policy/epad/english/pubs/adhoc/camc/toc.htm>

———. 1998. *A Portrait of the Canadian Agri-Food System June 1998*. Agriculture and Agri-Food Canada, Economic and Policy Analysis Directorate, Ottawa. Available on the Internet at <http://aceis.agr.ca/policy/epad/english/pubs/chrtbook/jun98/toc-pdf.htm>

———. 1998. *Rural Solutions to Rural Concerns*. Final Report of the National Rural Workshop, October 2–4, 1998. Agriculture and Agri-Food Canada, Ottawa.

———. 1999. *Quarterly Agri-Food Trade Highlights: Fourth Quarter 1998*. Agriculture and Agri-Food Canada, Economic and Policy Analysis Directorate, Ottawa. Available on the Internet at <http://www.agr.ca/policy/epad/english/pubs/qtrhigh/1998/4th/4thqtr98.pdf>

Alberta Agriculture, Food and Rural Development. 1998. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment*. Report for the Canada–Alberta Environmentally Sustainable Agriculture Agreement. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta.

Batie, S.S., and C.A. Cox. 1994. *Soil and Water Quality: An Agenda for Agriculture*. A Summary. *Journal of Soil and Water Conservation* 49(5):456–462.

Biodiversity Science Assessment Team. 1994. *Biodiversity in Canada: A Science Assessment for Environment Canada*. Environment Canada, Ottawa.

Canadian Council of Ministers of the Environment. 1999. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Global Change Program. 1995. Looking Ahead: Long-Term Ecological Research and Monitoring in Canada. Final Report of the Long-Term Ecological Research and Monitoring Panel of the Canadian Global Change Program. Canadian Global Change Program Technical Report Series No. 95-1. Royal Society of Canada, Ottawa.

Carter, M.R. 1994. A Review of Conservation Tillage Strategies for Humid Temperate Regions. *Soil & Tillage Research* 31(4):289–301.

Coote, D.R., and L.J. Gregorich (eds.). 2000. The Health of Our Water: Toward Sustainable Agriculture in Canada. Agriculture and Agri-Food Canada, Research Branch, Ottawa.

Coxworth, E., M.H. Entz, S. Henry, K.C. Bamford, A. Schoofs, P.D. Ominski, P. Leduc, and G. Burton. 1995. Study of the Effect of Cropping and Tillage Systems on the Carbon Dioxide Released by Manufactured Inputs to Western Canadian Agriculture: Identification of Methods to Reduce Carbon Dioxide Emissions. Agriculture and Agri-Food Canada, Lethbridge, Alberta.

Deloitte and Touche Management Consultants. 1993. Methyl Bromide Alternatives, Substitutes and Recovery Systems. Final Report. Prepared for Agriculture and Agri Food Canada, Ottawa.

Desjardins, R.L. 1998. Agroecosystem Greenhouse Gas Balance Indicator: Methane Component. Report No. 21 to the Agri-Environmental Indicator Project. Agriculture and Agri-Food Canada, Ottawa.

Doran, J.W., and T.B. Parkin. 1994. Defining and Assessing Soil Quality. In *Defining Soil Quality for a Sustainable Environment*, SSSA Special Publication No. 35, J.W. Doran, D.C. Coleman, D.F. Bezdicek, and B.A. Stewart (eds.), pp. 3–21. Soil Science Society of America and American Society of Agronomy, Madison, Wisconsin.

Dumanski, J., D.R. Coote, G. Luciuk, and C. Lok. 1986. Soil Conservation in Canada. *Journal of Soil and Water Conservation* 41:204–210.

Dumanski, J., L.J. Gregorich, V. Kirkwood, M.A. Cann, J.L.B. Culley, and D.R. Coote. 1994. The Status of Land Management Practices on Agricultural Land in Canada. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa.

Duxbury, J.M., and A.R. Mosier. 1993. Status and Issues Concerning Agricultural Emissions of Greenhouse Gases. In *Agricultural Dimensions of Global Climate Change*, T. Drennen and H.M. Kaiser (eds.), ch. 12. St. Lucie Press, Delray Beach, Florida.

Ecological Stratification Working Group. 1996. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada and Environment Canada, Ottawa. Available on the Internet at [http://res.agr.ca/CANSIS/PUBLICATIONS/ECOSTRAT/\\_overview.html](http://res.agr.ca/CANSIS/PUBLICATIONS/ECOSTRAT/_overview.html)

Eilers, R.G., W.D. Eilers, and M.M. Fitzgerald. 1997. A Salinity Risk Index for Soil of the Canadian Prairies. *Hydrogeology Journal* 5:68–79.

Eilers, R.G., W.D. Eilers, W.W. Pettapiece, and G. Lelyk. 1995. Salinization of Soil. In *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, D.F. Acton and L.J. Gregorich (eds.), pp.77–86. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological

Resources Research, Ottawa. Available on the Internet at  
<http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter08.html>

Environment Canada. 1993. Groundwater: Nature's Hidden Treasure. Freshwater Series A-5. Environment Canada, Ottawa.

Food and Agricultural Policy Research Institute. 1999. FAPRI 1999 World Agricultural Outlook. Staff Report 2-99. Iowa State University and University of Missouri–Columbia, Ames, Iowa.

Government of Canada. 1998. Canada's Action Plan for Food Security: A Response to the World Food Summit. Government of Canada, Ottawa.

———. 1998. Rural Canadians Speak Out. Summary of Rural Dialogue Input for the National Rural Workshop, October 2–4, 1998. Government of Canada, Ottawa. Available on the Internet at  
[http://www.rural.gc.ca/discpaper\\_e.html](http://www.rural.gc.ca/discpaper_e.html)

———. 1998. "Think Rural" and the Canadian Rural Partnership. Government of Canada, Ottawa.

———. N.d. Rural Canada: A Profile. Government of Canada, Ottawa.

Gregorich, E.G., D.A. Angers, C.A. Campbell, M.R. Carter, C.F. Drury, B.H. Ellert, P.H. Groenevelt, D.A. Holmstrom, C.M. Monreal, H.W. Rees, R.P. Voroney, and T.J. Vyn. 1995. Changes in Soil Organic Matter. In *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, D.F. Acton and L.J. Gregorich (eds.), pp. 41–50. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at  
<http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter05.html>

Gribbon, J., and M. Gribbon. 1996. The Greenhouse Effect. *The New Scientist* 2027, Supplement: Inside Science 92:1–4.

Griggs, D.J., and F.M. Courtney. 1985. *Agriculture and Environment: The Physical Geography of Temperate Agricultural Systems*. Longman Group Limited, New York.

Hardaker, J.B. 1997. Guidelines for the Integration of Sustainable Agriculture and Rural Development into Agricultural Policies. FAO Agricultural Policy and Economic Development Series, Number 4. Food and Agricultural Organization of the United Nations, Rome.

Hargrove, W.L. (ed.). 1991. *Cover Crops for Clean Water*. Soil and Water Conservation Society, Ankeny, Iowa.

Harker, D.B., K. Bolton, L. Townley-Smith, and B. Bristol. 1997. *A Prairie-wide Perspective of Nonpoint Agricultural Effects on Water Quality*. Prairie Farm Rehabilitation Administration, Agriculture and Agri-Food Canada, Regina, Saskatchewan.

Hog Environmental Strategy Steering Committee. 1997. *Hog Environmental Management Strategy: Situation Analysis*. Agriculture and Agri-Food Canada and the Canadian Pork Council, Ottawa.

Houghton, J. 1997. *Global Warming: The Complete Briefing*. Cambridge University Press, Cambridge, Massachusetts.

Houghton, J.T., L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.). 1996. *Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University

Press, Cambridge. Summary for policymakers available on the Internet at [http://www.ipcc.ch/pub/sa\(E\).pdf](http://www.ipcc.ch/pub/sa(E).pdf)

Janzen, H.H., R.L. Desjardins, J.M.R. Asselin, and B. Grace (eds.). 1999. *The Health of Our Air: Toward Sustainable Agriculture in Canada*. Agriculture and Agri-Food Canada, Research Branch, Ottawa.

Kay, B.D. 1990. Rates of Change of Soil Structure under Different Cropping Systems. *In Advances in Soil Science*, B.A. Steward (ed.), vol. 12, pp.1–52. Springer-Verlag, New York.

Kurvits, T., and T. Marta. 1998. Agricultural NH<sub>3</sub> and NO<sub>x</sub> emissions in Canada. *In Proceedings of the First International Conference on Nitrogen*, K.W. von der Hoek, J.W. Erisman, S. Smeulders, J.R. Wisaiewski, and J. Wisniewski (eds.), pp. 187–194. Elsevier Science, Amsterdam.

Larney, F.J., C.W. Lindwall, R.C. Izaurralde, and A.P. Moulin. 1994. Tillage Systems for Soil and Water Conservation on the Canadian Prairie. *In Conservation Tillage in Temperate Agroecosystems: Development and Adaptation to Soil, Climatic and Biological Constraints*, M.R. Carter (ed.), pp. 305–328. Lewis Publishers/CRC Press, Boca Raton, Florida.

Linton, J. 1997. *Beneath the Surface: The State of Water in Canada*. Canadian Wildlife Federation, Ottawa.

Marcotte, M., and C. Tibelius. 1998. *Improving Food and Agriculture Productivity and the Environment (Canadian Initiatives in Methyl Bromide Alternatives and Emission Control Technologies)*. Prepared for Agriculture and Agri-Food Canada, Ottawa.

MacDonald, K.B., W.R. Fraser, F. Wang, and G.W. Lelyk. 1995. A Geographical Framework for Assessing Soil Quality. *In The Health of Our Soils: Toward Sustainable Agriculture in Canada*, D.F. Acton and L.J. Gregorich (eds.), pp. 19–30. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at <http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter03.html>

McRae, T., C.A.S. Smith, and L.J. Gregorich (eds.). 2000. *Environmental Sustainability of Canadian Agriculture: Report of the Agri-Environmental Indicator Project*. Agriculture and Agri-Food Canada, Ottawa. In press.

Monteverde, C.A., R.K. Desjardins, and E. Pattey. 1998. *Agroecosystem Greenhouse Gas Balance Indicator: Nitrous Oxide Component*. Report No. 20 to the Agri-Environmental Indicator Project. Agriculture and Agri-Food Canada, Ottawa.

Moss, A.R. 1993. *Methane: Global Warming and Production by Animals*. Chalcome Publications, Kingston, U.K.

Narayanan, S. 1995. *Input Use Efficiency Indicator: Use Efficiency for Fertilizers, Pesticides, and Energy*. Report No. 11 to the Agri-Environmental Indicator Project. Agriculture and Agri-Food Canada, Ottawa.

Ontario Ministry of Agriculture, Food and Rural Affairs and Agriculture and Agri-Food Canada. 1992–1999. *Best Management Practices Series: Farm Forestry and Habitat Management; Field Crop Production; Horticultural Crops; Integrated Pest Management; Irrigation Management; Livestock and Poultry Management; No-till: Making it Work; Nutrient Management; Nutrient Management*

Planning; Pesticide Storage, Handling, and Application; Soil Management; Water Management; Water Wells. Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, Ontario.

Organisation for Economic Co-operation and Development. 1997. Environmental Benefits from Agriculture: Issues and Policies. The Helsinki Seminar. Organisation for Economic Co-operation and Development, Paris.

———. 1997. Environmental Indicators for Agriculture. Organisation for Economic Co-operation and Development, Paris.

———. 1999. Environmental Indicators for Agriculture: Issues and Design. The York Workshop. Organisation for Economic Co-operation and Development, Paris.

Parr, J.W., R.L. Papendick, S.B. Hornick, and R.E. Mayer. 1992. Soil Quality: Attributes and Relationship to Alternative and Sustainable Agriculture. *Journal of Alternative Agriculture* 7:5–11.

Paul, E.H., and G.D. Robertson. 1989. Ecology and the Agricultural Sciences: A False Dichotomy? *Ecology* 70:1594–1597.

Power, J.W. 1994. Understanding the Basics: Understanding the Nutrient Cycling Process. Nutrient Management, Special Supplement to *Journal of Soil and Water Conservation* 49(2):16–23.

Reganold, J.P., R.L. Papendick, and J.W. Parr. 1990. Sustainable Agriculture. *Scientific American*, June:112–120.

Reynolds, W.D., C.A. Campbell, C. Chang, C.M. Cho, J.H. Ewanek, R.G. Kachanoski, J.A. MacLeod, P.H. Milburn, R.R. Simard, G.R.B. Webster, and B.J. Zebarth. 1995. Agrochemical Entry into Groundwater. In *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, D.F. Acton and L.J. Gregorich (eds.), pp. 97–109. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at <http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter10.html>

Science Council of Canada. 1986. A Growing Concern: Soil Degradation in Canada. Science Council of Canada, Ottawa.

Shelton, I.J., and G.J. Wall (eds.). 1998. Indicator of Risk of Soil Degradation, Erosion Component: The Risk of Soil Erosion in Canada. Report No. 25 to the Agri-Environmental Indicator Project. Agriculture and Agri-Food Canada, Ottawa.

Smith, W.N., P. Rochette, C. Monreal, R.L. Desjardins, E. Pattey, and A. Jaques. 1997. The Rate of Carbon Change in Agricultural Soils in Canada at the Landscape Level. *Canadian Journal of Soil Science* 77:219–229.

Soil at Risk: Canada's Eroding Future. A Report on Soil Conservation by the Standing Committee on Agriculture, Fisheries, and Forestry to the Senate of Canada. 1984. Senate of Canada, Ottawa.

Statistics Canada. Rural and Small Town Canada: Analysis Bulletin. Published irregularly by Statistics Canada, Agriculture Division, Ottawa.

Surgenor, G.A. 1995. Sustainable Agriculture: Heaven on Earth? Agri-Food Research in Ontario, Special edition July:2–6. Agri-Food Research in Ontario is published biannually by the Ontario Ministry of Agriculture, Food and Rural Affairs, Toronto. Available on the Internet at

<http://www.gov.on.ca:80/OMAFRA/english/research/magindex.html>

Symbiotics Environmental Research and Consulting. 1997. Agricultural Sources, Effects and Abatement of Atmospheric Emissions of Nitrogen Compounds: Review of Canadian Science and Technology. Report prepared for Agriculture and Agri-Food Canada, Environment Bureau, Ottawa.

Tenuta, M., E.G. Beauchamp, and G.W. Thurtell. 1995. Studies of Nitrous Oxide Production and Emission from Soil: Evaluation of N<sub>2</sub>O Release with Different Methods and Fertilizer Sources. Final Report to the Trace Gas Initiative Project of Agriculture and Agri-Food Canada. Agriculture and Agri-Food Canada, Ottawa.

Think Rural! Report of the Standing Committee on Natural Resources. 1997. House of Commons, Ottawa.

Topp, G.C., K.C. Wires, D.A. Angers, M.R. Carter, J.L.B. Culley, D.A. Holmstrom, B.D. Kay, G.P. Lafond, D.R. Langille, R.A. McBride, G.T. Patterson, E. Perfect, V. Rasiah, A.V. Rodd, and K.T. Webb. 1995. Changes in Soil Structure. *In* The Health of Our Soils: Toward Sustainable Agriculture in Canada, D.F. Acton and L.J. Gregorich (eds.), pp. 51–60. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at <http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter06.html>

Wall, G.J., E.A. Pringle, G.A. Padbury, H.W. Rees, J. Tajek, L.J.P. van Vliet, C.T. Stushnoff, R.G. Eilers, and J.-M. Cossette. 1995. Erosion. *In* The Health of Our Soils: Toward Sustainable Agriculture in Canada., D.F. Acton and L.J. Gregorich (eds.), pp. 61–76. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at <http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter07.html>

Wang, C., L.J. Gregorich, H.W. Rees, B.D. Walker, D.A. Holmstrom, E.A. Kenney, D.J. King, L.M. Kozak, W. Michalyna, M.C. Nolin, K.T. Webb, and E.F. Woodrow. 1995. Benchmark Sites for Monitoring Agricultural Soil Quality. *In* The Health of Our Soils: Toward Sustainable Agriculture in Canada, D.F. Acton and L.J. Gregorich (eds.), pp. 31–40. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at <http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter04.html>

Wardle, D.I., J.B. Kerr, C.T. McElroy, and D.R. Francis (eds.). 1997. Ozone Science: A Canadian Perspective on the Changing Ozone Layer. Environment Canada, Ottawa.

Webber, M.D., and S.S. Singh. 1995. Contamination of Agricultural Soils. *In* The Health of Our Soils: Toward Sustainable Agriculture in Canada, D.F. Acton and L.J. Gregorich (eds.), pp. 87–96. Publication 1906/E. Agriculture and Agri-Food Canada, Centre for Land and Biological Resources Research, Ottawa. Available on the Internet at <http://res.agr.ca/CANSIS/PUBLICATIONS/HEALTH/chapter09.html>

Weseen, S., R. Lindenbach, and A. Lefebvre. 1999. Indicator of Energy Use Efficiency in Canadian Agriculture. Report No. 28 to the Agri-Environmental Indicator Project. Agriculture and Agri-Food Canada, Ottawa.

World Food Summit. 1996. World Food Summit Plan of Action. Food and Agricultural Organization of the United Nations, Rome.

# WEB SITES

## [AGCare](http://www.agcare.org)

<http://www.agcare.org>

## [Agricultural Adaptation Council](http://www.adaptcouncil.org)

<http://www.adaptcouncil.org>

## [Agriculture and Agri-Food Canada](http://www.agr.ca)

<http://www.agr.ca>

## [Agriculture and Food Council](http://www.agfoodcouncil.com)

<http://www.agfoodcouncil.com>

## [Association of Universities and Colleges of Canada](http://www.aucc.ca)

<http://www.aucc.ca>

## [Atlantic Canada Opportunities Agency](http://www.acoa.ca)

<http://www.acoa.ca>

## [B.C. and Canadian Farm Women's Network](http://www.island.net/~awpb/aware/id41.html)

<http://www.island.net/~awpb/aware/id41.html>

## [Biotechnology Research Institute](http://www.bri.nrc.ca/bri-1b.htm)

<http://www.bri.nrc.ca/bri-1b.htm>

## [Brewers Association of Canada](http://www.brewers.ca)

<http://www.brewers.ca>

## [Canada Beef Export Federation](http://www.cbef.com)

<http://www.cbef.com>

## [Canada Grains Council](http://www.canadagrainscouncil.ca)

<http://www.canadagrainscouncil.ca>

## [Canada Institute for Scientific and Technical Information](http://www.cisti.nrc.ca/cisti/cisti.html)

<http://www.cisti.nrc.ca/cisti/cisti.html>

## [Canadian Agricultural Economics Society](http://www.caes-scae.org)

<http://www.caes-scae.org>

## [Canadian Agri-Food Marketing Council](http://www.camc-ccca.org)

<http://www.camc-ccca.org>

## [Canadian Agri-Food Research Council](http://www.carc-crac.ca)

<http://www.carc-crac.ca>

## [Canadian Alliance of Agri-Food Exporters](http://www.agexportersalliance.org)

<http://www.agexportersalliance.org>

## [Canadian Botanical Association](#)

<http://www.uoguelph.ca/botany/cba/index.htm>

[Canadian Cattlemen's Association](#)

<http://www.cattle.ca>

[Canadian Chemical Producers' Association](#)

<http://www.ccpa.ca>

[Canadian Council of Grocery Distributors](#)

<http://www.ccgd.ca>

[Canadian Council of Ministers of the Environment](#)

<http://www.ccme.ca>

[Canadian Dairy Commission](#)

<http://www.cdc.ca/index.html>

[Canadian Egg Marketing Agency](#)

<http://www.canadaegg.ca>

[Canadian Environmental Assessment Agency](#)

<http://www.ceaa.gc.ca>

[Canadian Environmental Network](#)

<http://www.cen.web.net>

[Canadian Environmental Quality Guidelines](#)

<http://www.ec.gc.ca/ceqg-rcqe/index.htm>

[Canadian Farm Business Management Council](#)

<http://www.eap.mcgill.ca/cfbmc.htm>

[Canadian Federation of Agriculture](#)

<http://www.cfa-fca.ca>

[Canadian Federation of Independent Grocers](#)

<http://www.cfig.ca>

[Canadian Feed Industry Association](#)

<http://www.magma.ca/~cfia>

[Canadian Fertilizer Institute](#)

<http://www.cfi.ca>

[Canadian Food Brokers Association](#)

<http://www.cfba.com>

[Canadian Food Inspection Agency](#)

<http://www.cfia-acia.agr.ca>

[Canadian Global Change Program](#)

[http://www.globalcenters.org/cgcp/english/html\\_documents/eindex.html](http://www.globalcenters.org/cgcp/english/html_documents/eindex.html)

[Canadian Grain Commission](#)

<http://www.cgc.ca>

[Canadian Institute for Environmental Law and Policy](#)

<http://www.cielap.org/>

[Canadian Institute of Food Science and Technology](#)

<http://www.cifst.ca>

[Canadian International Development Agency \(CIDA\)](#)

<http://www.acdi-cida.gc.ca>

[Canadian International Grains Institute](#)

<http://www.cigi.ca>

[Canadian Meat Council](#)

<http://www.canswine.ca/pack.html>

[Canadian Museum of Nature](#)

<http://www.nature.ca>

[Canadian Organic Advisory Board](#)

<http://www.coab.ca>

[Canadian Organic Growers](#)

<http://www.gks.com/cog>

[The Canadian Pollution Prevention Information Clearinghouse](#)

<http://www.ec.gc.ca/cppic>

[Canadian Pork Council](#)

<http://www.canpork.ca>

[Canadian Produce Marketing Association](#)

<http://www.cpma.ca>

[Canadian Rural Information Service](#)

<http://www.agr.ca/policy/cris>

[Canadian Rural Partnership](#)

<http://www.rural.gc.ca>

[Canadian Seed Growers' Association](#)

<http://www.seedgrowers.ca>

[Canadian Seed Trade Association](#)

<http://www.cdnseed.org>

[Canadian Sheep Federation](#)

<http://www.cansheep.ca>

[Canadian Swine Exporters Association](#)

<http://www.execulink.com/~csea/csea.html>

[Canadian Turkey Marketing Agency](#)

<http://www.canturkey.ca>

[Canadian Venison Council](#)

<http://www.cybercervus.com/assoc/cvc.html>

[Canadian Water and Wastewater Association](#)

<http://www.cwwa.ca>

[Canadian Water Resources Association](#)

<http://www.cwra.org>

[Canadian Wheat Board](#)

<http://www.cwb.ca>

[Canadian Wildlife Federation](#)

<http://www.cwf-fcf.org>

[Canadian Wildlife Service](#)

[http://www.ec.gc.ca/cws-scf/cwshom\\_e.html](http://www.ec.gc.ca/cws-scf/cwshom_e.html)

[Chicken Farmers of Canada](#)

<http://www.chicken.ca>

[Commission on Sustainable Development](#)

<http://www.un.org/esa/sustdev/csd.htm>

[Commissioner of the Environment and Sustainable Development](#)

[http://www.oag-bvg.gc.ca/domino/cesd\\_cedd.nsf/html/menu\\_e.html](http://www.oag-bvg.gc.ca/domino/cesd_cedd.nsf/html/menu_e.html)

[Crop Protection Institute](#)

<http://www.cropro.org>

[Dairy Farmers of Canada:](#)

<http://www.dairyfarmers.org>

[Department of Foreign Affairs and International Trade](#)

<http://www.dfait-maeci.gc.ca>

[Ducks Unlimited Canada](#)

<http://www.ducks.ca>

[Earth Summit+5](#)

<http://www.un.org/esa/earthsummit>

[Ecological Monitoring and Assessment Network](#)

<http://www.cciw.ca/eman/intro.html>

[Emergency Preparedness Canada](#)

<http://hoshi.cic.sfu.ca/epc>

[Environment Bureau, Agriculture and Agri-Food Canada](#)

<http://www.agr.ca/policy/environment>

[Environment Canada](#)

<http://www.ec.gc.ca>

[Environmental Health Program](#)

<http://www.hc-sc.gc.ca/ehp/ehd>

[Export Development Corporation](#)

<http://www.edc.ca>

[Federation of Canadian Municipalities](#)

<http://www.fcm.ca>

[Fisheries and Oceans](#)

<http://www.ncr.dfo.ca>

[Food Beverage Canada](#)

<http://www.foodbeveragecanada.com>

[Food Institute of Canada—FoodNet](#)

<http://foodnet.fic.ca>

[Geological Survey of Canada](#)

<http://www.nrcan.gc.ca/gsc>

[Government of Alberta](#)

<http://www.gov.ab.ca>

[Government of British Columbia](#)

<http://www.gov.bc.ca>

[Government of Canada](#)

<http://www.gc.ca>

[Government of Manitoba](#)

<http://www.gov.mb.ca>

[Government of New Brunswick](#)

<http://www.gov.nb.ca>

[Government of Newfoundland and Labrador](#)

<http://www.gov.nf.ca>

[Government of Nova Scotia](#)

<http://www.gov.ns.ca>

[Government of Nunavut](#)

<http://www.gov.nu.ca>

[Government of Ontario](#)

<http://www.gov.on.ca>

[Government of Prince Edward Island](#)

<http://www.gov.pe.ca>

[Government of Quebec](#)

<http://www.gouv.qc.ca/XMLDev/Site/Dhtml/Anglais/IndexA.html>

[Government of Saskatchewan](#)

<http://www.gov.sk.ca>

[Government of Yukon](#)

<http://www.gov.yk.ca>

[Great Lakes Information Network](#)

<http://www.great-lakes.net>

[Health Canada](#)

<http://www.hc-sc.gc.ca>

[House of Commons Standing Committee on Agriculture and Agri-Food](#)

<http://www.parl.gc.ca/36/1/parlbus/commbus/house/CommitteeMain.asp?Language=E&CommitteeID=66>

[Human Resources Development Canada](#)

<http://www.hrdc-drhc.gc.ca>

[Indian and Northern Affairs Canada](#)

<http://www.inac.gc.ca>

[Industry Canada](#)

<http://www.ic.gc.ca>

[Insect Biotech Canada](#)

<http://www.zoo.utoronto.ca/insectbiotechcan>

[International Development Research Centre \(IDRC\)](#)

<http://www.idrc.ca/en>

[International Joint Commission](#)

<http://www.ijc.org>

[Man and the Biosphere—Canada/MAB Program](#)

<http://www.cciw.ca/mab/intro.html>

[Ministère de l'Environnement du Québec](#)

<http://www.menv.gouv.qc.ca/index-en.htm>

[National Atlas of Canada Online](#)

<http://www.atlas.gc.ca>

[National Dairy Council of Canada](#)

<http://www.cnil.ca>

[National Farm Products Council](#)

<http://www.nfpc-cnpa.gc.ca>

[National Farmers Union](#)

<http://www.nfu.ca>

[National Round Table on the Environment and the Economy](http://www.nrtee-trnee.ca)

<http://www.nrtee-trnee.ca>

[National Water Research Institute](http://www.cciw.ca/nwri-e/intro.html)

<http://www.cciw.ca/nwri-e/intro.html>

[Natural Resources Canada](http://www.nrcan.gc.ca)

<http://www.nrcan.gc.ca>

[Nature Conservancy of Canada](http://www.natureconservancy.ca)

<http://www.natureconservancy.ca>

[North American Waterfowl Management Plan](http://www.wetlands.ca/nawcc/nawmp)

<http://www.wetlands.ca/nawcc/nawmp>

[North American Wetlands Conservation Council \(Canada\)](http://www.wetlands.ca/nawcc)

<http://www.wetlands.ca/nawcc>

[Organisation for Economic Co-operation and Development](http://www.oecd.org)

<http://www.oecd.org>

[Pest Management Regulatory Agency:](http://www.hc-sc.gc.ca/pmra-arla/qcont-e.html)

<http://www.hc-sc.gc.ca/pmra-arla/qcont-e.html>

[Plant Biotechnology Institute](http://www.pbi.nrc.ca)

<http://www.pbi.nrc.ca>

[Prairie Farm Rehabilitation Administration](http://www.agr.ca/pfra)

<http://www.agr.ca/pfra>

[Resource Futures International](http://www.rfi.on.ca)

<http://www.rfi.on.ca>

[Royal Society of Canada](http://www.rsc.ca)

<http://www.rsc.ca>

[Rural Living Canada](http://kenrussellassociates.bizland.com/rural.htm)

<http://kenrussellassociates.bizland.com/rural.htm>

[Saskatchewan Irrigation Diversification Centre \(SIDC\)](http://www.agr.ca/pfra/sidcgene.htm)

<http://www.agr.ca/pfra/sidcgene.htm>

[Soil and Water Conservation Society \(Alberta Chapter\)](http://www.compusmart.ab.ca/swcsalta)

<http://www.compusmart.ab.ca/swcsalta>

[St. Lawrence Vision 2000 Action Plan](http://www.slv2000.qc.ec.gc.ca/plan_action/phase3/accueil_a.htm)

[http://www.slv2000.qc.ec.gc.ca/plan\\_action/phase3/accueil\\_a.htm](http://www.slv2000.qc.ec.gc.ca/plan_action/phase3/accueil_a.htm)

[The State of Canada's Environment Infobase](http://www1.ec.gc.ca/~soer)

<http://www1.ec.gc.ca/~soer>

[Statistics Canada](http://www.statcan.ca)

<http://www.statcan.ca>

[Transport Canada](http://www.tc.gc.ca)

<http://www.tc.gc.ca>

[United Nations](http://www.un.org)

<http://www.un.org>

[United Nations Development Programme](http://www.undp.org)

<http://www.undp.org>

[United Nations Environment Programme](http://www.unep.org)

<http://www.unep.org>

[Western Canadian Wheat Growers Association](http://www.wcwga.ca)

<http://www.wcwga.ca>

[Wildlife Habitat Canada](http://www.whc.org)

<http://www.whc.org>

[World Bank Group — Environment Sector](http://www.worldbank.org/environment/)

<http://www.worldbank.org/environment/>

[World Business Council for Sustainable Development:](http://www.worldbank.org/environment/)

<http://www.worldbank.org/environment/>

[World Health Organization](http://www.who.org)

<http://www.who.org>

[World Wildlife Fund Canada](http://www.wwfcanada.org)

<http://www.wwfcanada.org>

[Worldwatch Institute](http://www.worldwatch.org)

<http://www.worldwatch.org>

---

| [The Green Lane](#) | [Search](#) | [Contact Us](#) | [Canada Site](#) | [Sustainable Development](#) | [Monographs](#) | [Splash Page](#) | [Français](#) |

[Comments to:](#)

Conservation Priorities and Planning Branch

**URL of this page:** <http://www.ec.gc.ca/agenda21/2000/agriculteng.htm>

**Information last updated:** February 2001

[Copyright © 2000](#). All rights reserved.

[The Green Lane](#) is a registered trademark of Environment Canada.

You are on [The Green Lane](#)<sup>TM</sup>, Environment Canada's World Wide Web Site.