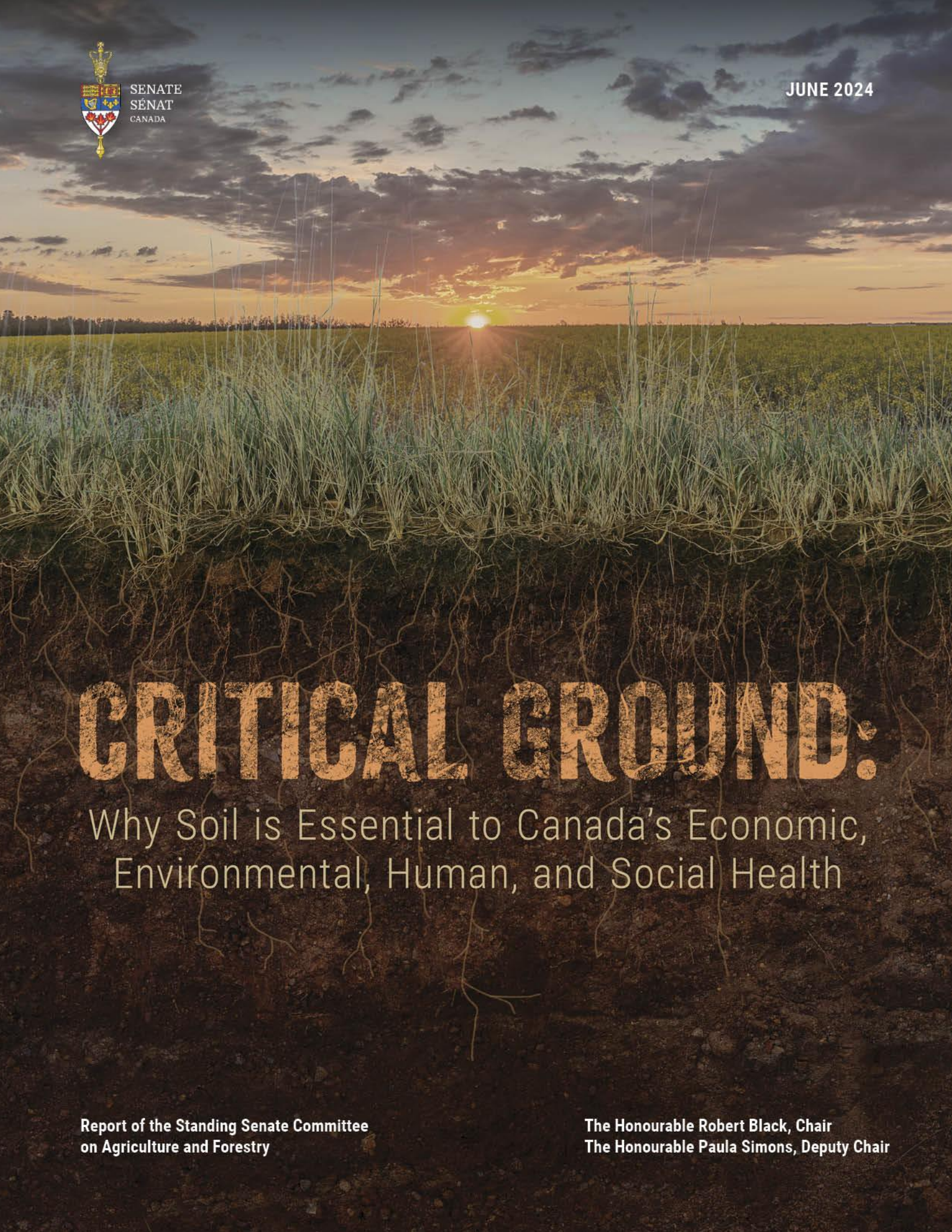

SENATE
SÉNAT
CANADA

JUNE 2024

CRITICAL GROUND:

Why Soil is Essential to Canada's Economic, Environmental, Human, and Social Health

Report of the Standing Senate Committee on Agriculture and Forestry

The Honourable Robert Black, Chair
The Honourable Paula Simons, Deputy Chair

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TABLE OF CONTENTS

FOREWARD

We acknowledge that our work takes place on the ancestral lands of Indigenous peoples who have stewarded these territories since time immemorial. We honour their enduring relationship with the land and commit to fostering mutual respect and collaboration as we move forward together.

As we stand on the dawn of a new era defined by environmental challenges and agricultural innovation, the importance of soil health in Canada has never been more profound. This report on the status of soil health in Canada is a testament to our continued commitment to understanding, preserving, and enhancing the very foundation of our country.

Soil is, and always has been more than mere earth beneath our feet; it is the lifeblood of our nation's growth, sustenance, and prosperity. From the vast prairies of the West to the resiliency of the North to the fertile valleys of the East, Canada's soils have sustained generations of farmers, nurtured diverse ecosystems, and supported a thriving agricultural sector that is the envy of the world.

Yet, the health of our soils is facing unprecedented challenges. Climate change, land degradation, and evolving agricultural practices necessitate a comprehensive understanding of soil dynamics, resilience, and management strategies.

This report delves deep into these issues, offering insights, analyses, and recommendations that are vital for safeguarding our soil resources for generations to come.

I commend and thank the dedicated efforts of all the researchers, scientists, policymakers, farmers, ranchers, foresters, and stakeholders whose contributions have greatly enriched this report. Their expertise, passion, and commitment to soil health serve as a beacon of hope and progress in our journey towards a more sustainable and resilient agricultural future.

May this report inspire action, foster collaboration, and ignite a renewed sense of stewardship towards our precious soils. Together, let us embark on a transformative journey towards a greener, healthier, and more prosperous Canada, rooted in the timeless legacy of our soils.

I wish to acknowledge our former colleagues who spearheaded the 1984 Senate report… the first report of its kind and still in high demand today; those early adopters who took up the challenge of improving soil health in Canada; and those men and women who encouraged this committee to undertake an updated report on the status of soil health in Canada. This report is for you.

Sincerely,

The Honourable Robert Black
Senator – Ontario
Chair, Senate Standing Committee on Agriculture and Forestry

THE COMMITTEE MEMBERSHIP

The Honourable Robert BLACK
Chair

The Honourable Paula SIMONS
Deputy Chair

The Honourable Senators

Sharon Burey

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Marty Klyne

John M. McNair

Donald Neil Plett

Victor Oh

Chantal Petitclerc

Ex-officio members of the committee:

The Honourable Senator Gold and/or the Honourable Senator LaBoucane-Benson
The Honourable Senator Plett and/or the Honourable Senator Martin
The Honourable Senator Saint-Germain and/or the Honourable Senator Clement
The Honourable Senator Tannas and/or the Honourable Senator Patterson
The Honourable Senator Dalphond and/or the Honourable Senator White

Other Senators who have participated in the study:

The Honourable David M. Arnot
The Honourable Michèle Audette
The Honourable Diane Bellemare
The Honourable Andrew Cardozo
The Honourable Jean-Guy Dagenais
The Honourable Colin Deacon (Nova Scotia)
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Ferda Simpson, Clerk
Elda Donnelly, Administrative Assistant

Senate Communications Directorate:
Ben Silverman, Communications Officer

ORDER OF REFERENCE

Extract from the *Journals of the Senate* of Tuesday, April 26, 2022:

The Honourable Senator Black moved, seconded by the Honourable Senator Downe:

That the Standing Senate Committee on Agriculture and Forestry be authorized to examine and report on the status of soil health in Canada with the purpose of identifying ways to improve soil health, enable Canadian forest product and agricultural producers to become sustainability leaders, and improve their economic prosperity;

That in particular, the committee should examine:

(a) current soil conditions in Canada;

(b) possible federal measures that would support and enhance agricultural and forest soil health, including in relation to conservation, carbon sequestration and efforts to address the effects of climate change;

(c) the implications of soil health for human health, food security, forest and agricultural productivity and prosperity, water quality and air quality; and

(d) the role of new technologies in managing and improving soil health; and

That the committee report to the Senate no later than December 31, 2023, and that the committee retain all powers necessary to publicize its findings for 180 days after the tabling of the final report.

The question being put on the motion, it was adopted.

Interim Clerk of the Senate

Gérald Lafrenière

Extract from the *Journals of the Senate* of Thursday, September 28, 2023:

The Honourable Senator Black moved, seconded by the Honourable Senator Smith:

That, notwithstanding the order of the Senate adopted on Tuesday, April 26, 2022, the date for the final report of the Standing Senate Committee on Agriculture and Forestry in relation to its study on the status of soil health in Canada be extended from December 31, 2023 to December 31, 2024; and

That the committee be permitted, notwithstanding usual practices, to deposit with the Clerk of the Senate its report relating to this study, if the Senate is not then sitting, and that the report be deemed to have been tabled in the Senate.

The question being put on the motion, it was adopted.

Interim Clerk of the Senate

Gérald Lafrenière

EXECUTIVE SUMMARY

The Standing Senate Committee on Agriculture and Forestry (the committee) completed a new study on the status of soil health in Canada. The committee learned that soil delivers ecosystem services that enable all—plant, animal, human—life on Earth, such as water purification and storage; climate and flood regulation; nutrient cycling; carbon sequestration; the provision of food, fibre, fuel, and construction materials; habitat for organisms; and the foundation for human infrastructure and cultural heritage.

Soil is as critical as the air we breathe and the water we drink. Soil health is human health is *One Health*.[1] Yet, soil is still at risk in Canada and around the world. Since the 1984 Senate report, the committee heard that while soil management has improved and crop yield has increased with enhanced plant genetics and cultural practices, these gains have also masked the effect of continued soil degradation and loss of agricultural land in every region of Canada.[2] This is the result of climate change and more frequent extreme weather events (drought, fires, floods), urbanization, and misread outcomes of soil management practices. We do not have another 40 years to protect and conserve soil. We must act now.

> *"The sense of urgency is the evidence that we have of the degradation of soils worldwide being exacerbated by intense weather events and climate factors."*
>
> *Penny Wensley*[3]

The report explores many themes and presents recommendations to understand soil health, build soil-based incentives and initiatives, and promote soil health and agricultural and forestry land preservation for a better future. Through witness testimony and fact-finding missions, the committee learned about the valuable work that farmers, ranchers, growers, foresters, agronomists, researchers, and government officials are doing in every province and territory in Canada to improve soil degradation. We thank them for their time and the knowledge they shared about beneficial soil management practices, as well as the barriers to implementing them.

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[1] According to the World Health Organization, *One Health* is an integrated approach that aims to balance and optimize the health of people, animals, and the environment in a sustainable manner by recognizing that they are closely linked and interdependent.

[2] AGFO, *Evidence*, 22 September 2022 (Don Lobb, Farmer, As an individual).

[3] AGFO, *Evidence*, 29 February 2024 (Penny Wensley, Former National Soils Advocate, Government of Australia, As an individual).

Soil is a valuable natural resource. The Government of Canada should designate soil as a strategic national asset. Other countries such as Australia have appointed a national soils advocate; the committee believes that the Government of Canada should do the same.

The committee heard that while organizations such as the Soil Conservation Council of Canada have been developing a national soil strategy, there is no overarching federal strategy currently in place to protect and conserve agricultural and forestry soils in this country. Another issue facing the sector, and all Canadians, is the lack of available data on soil health. The Government of Canada must take a lead and collaborate with the provinces, territories, Indigenous governments, academia, and agricultural and forestry producers to collect, analyze, and share data on soil productivity, so that we can better understand and improve strategies to enhance our soils' capabilities.

Given the range of soil types and climates throughout Canada, the committee was repeatedly told that a 'one-size-fits-all-approach' to soil health does not work and that policymakers must consider regional differences. In Canada's North, melting permafrost—and the unknown amount of carbon it stores and releases—poses risks for agriculture and forestry in all three territories. The creation of a national permafrost assessment centre would enhance coordination and representation of these issues. The committee also heard that soil contamination is widespread in Canada. A national strategy for remediating contaminated soils throughout the country is imperative.

To protect and conserve farmland soil throughout Canada, the committee heard that all levels of government—federal, provincial, territorial, municipal—should work together to plan agriculture into, and not out of, communities. Witnesses also said that building soil-based incentives (tax credits for farmers, enhanced crop insurance, a viable carbon market), as well as sustained funding for soil research initiatives is imperative for producers' prosperity. Finally, witnesses suggested that the Government of Canada provide funding for peer-to-peer soil networks, extension services, soil science programs, and encourage the development of programming in elementary and high schools to enhance awareness and understanding of the economic, environmental, and social contributions that agriculture brings to this country.

The committee believes that a new path forward is needed; one that is based on collaboration between federal, provincial, territorial, municipal, and Indigenous governments, to ensure that the economic prosperity of agricultural and forestry producers is at the forefront of soil-related policymaking.

RECOMMENDATIONS

To Better Understand the State of Soil Health and Its Evolution, the Committee Recommends That:

1. The Government of Canada designate soil as a strategic national asset.
2. The Government of Canada appoint a national soils advocate.
3. The Government of Canada support the development of a long-term overarching strategy to protect and conserve soil throughout Canada and that this strategy include targets, timetables, and provisions for review.
4. That the Government of Canada collaborate with the provinces and territories to support the development of a consensus on how to measure, report, and verify soil health.
5. The Government of Canada collaborate with provinces, territories, Indigenous governments, academia, and agricultural and forestry producers to create a national soils institute and database; that this data be shared with provinces, territories, Indigenous governments, academia, and agricultural and forestry producers; and, that this data be collected at different points in time to adequately measure change over time.
6. The Government of Canada create a national permafrost assessment program.

To Build Soil-Related Incentives and Initiatives, the Committee Recommends That:

7. The Government of Canada encourage provinces, territories, and municipalities to develop measures—as a form of land use planning—that best preserve and protect agricultural land in their jurisdictions.
8. The Government of Canada collaborate with the provinces and territories to create and deliver a crop insurance model that incentivizes the ecological goods and services carried out by farmers, growers, and ranchers.
9. The Government of Canada help to facilitate and encourage the creation of viable and valuable carbon markets for farmers, ranchers, and growers.
10. The Government of Canada implement tax credits for farmers, ranchers, and growers who have adopted, or are adopting, innovation and technology that support soil health, and that the Government of Canada does not leave the early adopters behind.
11. The Government of Canada collaborate with the provinces and territories to expand and deliver higher quality broadband internet access in rural areas to promote a wider adoption of precision agriculture techniques to enhance soil health.
12. The Government of Canada enhance funding for public/private partnerships for research and development with respect to agricultural and forestry soils.

13. The Government of Canada collaborate with the provinces and territories to provide long-term funding for:
    - agricultural and forest soil mapping throughout the country, as well as for data aggregation;
    - a national topsoil sampling program; and,
    - flood mapping near agricultural lands.
14. The Government of Canada collaborate with the provinces and territories to:
    - extend the Living Laboratories Initiative to all parts of the agriculture sector;
    - update the agri-environmental indicators annually; and,
    - invest further in the AgriScience Program clusters.
15. The Government of Canada reinstate the Prairie Farm Rehabilitation Administration.

To Promote Soil Health, Human Health, and a Better Future, the Committee Recommends That:

16. The Government of Canada enhance funding for peer-to-peer soil networks that extends to all provinces and territories.
17. The Government of Canada collaborate with the provinces and territories to enhance long-term funding for soil extension services.
18. The Government of Canada collaborate with provinces, territories, and Indigenous governments to develop a national strategy for remediating contaminated soils throughout the country.
19. The Government of Canada collaborate with provinces, territories, and Indigenous governments to conduct more research on soil pollution to examine its impacts on human health.
20. The Government of Canada address policy gaps that fail to create opportunities for Indigenous communities that will be effective in supporting soil health.
21. The Government of Canada collaborate with the provinces and territories to enhance long-term funding for soils programming at post-secondary institutions and that this funding be sustained.
22. The Government of Canada provide financial support for and encourage the development of programming in elementary and high schools to enhance awareness and understanding of the environmental, social, and economic contributions that agriculture brings to our country.
23. The federal, provincial, and territorial governments, the national soils advocate, and relevant interested parties should commit to holding an annual national summit on soil health, and that the issue of soil health be the subject of each agriculture minister's agenda, leading to an annual report on soil health for the country.

24. The federal, provincial, and territorial governments give special consideration to the economic viability of agricultural and forestry producers in the development and implementation of all its future policies and programs related to soil health to ensure that producers are able to invest in soil health.
25. The Government of Canada recognize a sense of urgency and act accordingly. We do not have another 40 years to protect and conserve soil.

GLOSSARY

Agroforestry – a land management approach that intentionally blends agriculture and forestry to enhance productivity, profitability, and environmental stewardship.

Beneficial management practices – any on-farm management practices that reduces or eliminates an environmental risk.

Biodiversity – the variety and variability of life on Earth including animals, plants, fungi, and microorganisms such as bacteria.

Carbon sequestration – the capture, removal, and storage of carbon dioxide (CO_2) from the Earth's atmosphere by plants and trees in soils through the process of photosynthesis.

Compaction – the pressing together of soil particles, which reduces the space available for water and air.

Conservation tillage (including minimum-, no-, and zero-till(age) farming) – a method of planting crops with minimal disturbance of the soil. Planters or seeders insert seeds into the soil in a slot made by a disc opener.

Cover cropping – plants that are planted for the purpose of covering the soil rather than being harvested. Cover crops manage soil erosion, soil fertility, water, weeds, pests, diseases, biodiversity, and wildlife in agricultural systems.

Degradation – the physical, chemical, and biological decline in soil function and quality.

Early Adopters – the farmers, growers and ranchers who first adopted cultivation tillage, and other regenerative agriculture and carbon sequestration practices.

Ecological, or Ecosystem, Goods and Services (EG&S) – the benefits that humans receive from their ecosystems that are essential for healthy, functioning, and sustainable agricultural landscapes. EG&S are achieved through farm management practices (e.g., cover cropping) and that encourage the establishment and maintenance of natural habitats (e.g., forests, native prairie, wetlands) and semi-natural habitats (e.g., buffer strips, woodlots).

Erosion – the wearing away of topsoil by the natural physical forces of water and wind and through human activity such as tillage practices on agricultural land.

Food security –the physical, social, and economic access to sufficient, safe, and nutritious food that meets peoples' dietary needs and food preferences.[4]

Food sovereignty – the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems.

Grasslands – the vast prairie grasses that stretch across Alberta, Saskatchewan, and Manitoba.

Greenhouse gas emissions – gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) that are emitted by human activity into the atmosphere and that raise Earth's surface temperature.

Intercropping – sowing two, or more, crops simultaneously in alternate rows in the same field.

Permafrost – ground (soil or rock) that remains at a temperature of 0°C or lower for at least two years. Most permafrost in Canada also contains water in the form of ice.

Regenerative agriculture – a land management approach that considers the land's ecological system including the soil, water, and diversity of plant life, ensuring that every part of the ecosystem is healthy and working well together while increasing biodiversity and the land's resilience to climate change.

Salinization – the excessive accumulation of water-soluble salts in agricultural soils.

Soil cover days – amount of time in Canada that agricultural soils are covered by a crop, crop residues, or snow.

Soil health – the capacity of soils to function and deliver ecosystem services.

Soil organic carbon – the solid carbon that is stored in soils; a measurable component of soil organic matter.

Soil organic matter – the living microorganisms in soils and material from plants and organic compounds that have been formed through the decomposition of organic materials.

[4] World Health Organization [WHO], "Food Security & Nutrition: Essential Ingredients to Build Back Better," *Newsroom*, 18 October 2022.

Introduction

Canada is an agricultural country. In 2022, the whole agriculture and agri-food system employed 2.3 million people, provided 1 in 9 jobs in Canada, and generated $142.8 billion (approximately 7%) of the country's gross domestic product (GDP). Agricultural and food product exports totaled nearly $92.8 billion.[5]

Primary agriculture–work that is carried out within the boundaries of a farm, greenhouse, nursery, or ranch–is an economic driver and highly diversified throughout the country. In 2022, Canadian primary agriculture comprised 189,874 farms, provided 249,000 jobs in Canada, and generated $36.3 billion (1.8%) of the GDP. Farms covered 62.2 million hectares, or 6.2% of Canada's total land base.[6]

> *"Soils are a valuable and fragile asset. We know that a healthy fertile soil provides significant biodiversity and increased availability of nutrients, which improves crop yields and profitability."*
>
> *Benoit Legault*[7]

Soil is the foundation of Canada's agriculture and agri-food system and is as important as the air we breathe and the water we drink. Soil health is critical to human health. Soil health is human health is *One health*. All soils in Canada are located on the traditional territories of Indigenous peoples. The vastness of our country suggests an abundance of soil, yet only 6.7% of Canada's land is suitable for agricultural use.[8] Farmers, ranchers and growers depend on healthy soil to feed Canadians and the world sustainably while faced with the growing pressures of climate change.

[5] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[6] Ibid.
[7] AGFO, *Evidence*, 8 June 2023 (Benoit Legault, Director General, Producteurs de grains du Québec).
[8] Agriculture and Agri-Food Canada, *Report #4 - Agri-Environmental Indicator Report Series: Environmental Sustainability of Canadian Agriculture*, 2016.

Hands holding dark, rich soil from Wray Ranch near Irricana, Alberta.

> *"Climate change is one of the greatest challenges of the 21st century. Farmers and foresters are on the frontline of this change as the lives and livelihoods of those who feed, clothe and fuel the world are directly affected by a changing climate and weather extremes."*
>
> *World Farmers' Organisation*[9]

Healthy soils play a crucial role in addressing the urgent global challenges of climate change, biodiversity loss, and food security. Canada has international commitments, including reporting obligations under the following agreements, all of which relate to soil:

- Intergovernmental Panel on Climate Change (IPCC);
- United Nations Framework Convention on Climate Change (UNFCC);
- United Nations Convention on Biological Diversity (CBD) (to halt and reverse biodiversity loss);

[9] World Farmers' Organisation, *Policy on Climate Change and Agriculture*, 2019.

- United Nations Convention to Combat Desertification (UNCCD) (in countries experiencing serious drought and/or desertification);
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar, Iran) (Canada has one quarter of the world's total wetlands);
- Global Methane Initiative (GMI); and,
- Arctic Council.

Soil health is a cross-cutting issue. Soil is a valuable natural resource and a strategic national asset, which is at risk and must be conserved and protected. Soil should be seen as a natural resource and as a national policy priority.

> *"Soil is a non-renewable resource, generated slowly over a millennium or so to generate a centimetre of good-quality soil."*
>
> *Subhasis Ghoshal*[10]

Between May 2022 and February 2024, the committee conducted an in-depth study to explore the status of soil health conditions in Canada, and to identify ways to improve soil health, enable agricultural and forestry producers to become sustainability leaders, and improve their economic prosperity. Over two years of hearings, the committee heard from 153 witnesses, and received over 60 briefs, from soil science researchers, agronomists, farmers, ranchers, foresters, environmental organizations, agri-businesses, and industry groups and federal, provincial, and territorial governments.

[10] AGFO, *Evidence*, 15 February 2024 (Subhasis Ghoshal, Professor, Civil Engineering and Director, Trottier Institute for Sustainability in Engineering and Design, McGill University, As an individual).

Members of the Senate Committee on Agriculture and Forestry stand outside the Canada Agriculture and Food Museum in Ottawa. From left, Senator Mobina S.B. Jaffer, museum director general Kerry-Leigh Burchill, and senators Pat Duncan, Victor Oh, Brent Cotter, Rob Black and Paula Simons.

In summer 2022, the committee attended the World Congress of Soil Science 2022 in Glasgow, Scotland. In fall 2022, the committee visited the Soil Lab at the Canada Agriculture and Food Museum in Ottawa, Ontario. In 2023, it travelled to Guelph, Ontario, Saskatoon, Saskatchewan, Calgary, Alberta, and towns/villages near these cities, to meet directly with soil researchers, farmers, ranchers, growers, and other stakeholders. The committee attended the Eleventh Global Soil Plenary Partnership Assembly hosted by the Food and Agriculture Organization (FAO) of the United Nations in Rome, Italy and also met with the World Farmers' Organisation.

The committee wishes to thank the many witnesses who appeared before this committee. This report is informed by their testimony. Hopefully, this report informs readers and offers a road map for the future of sustaining and improving soil health in Canada.

Chapter 1: The Current State of Agricultural and Forest Soils in Canada

Soil mixed with leaves from the soil lab at the Canada Agriculture and Food Museum.

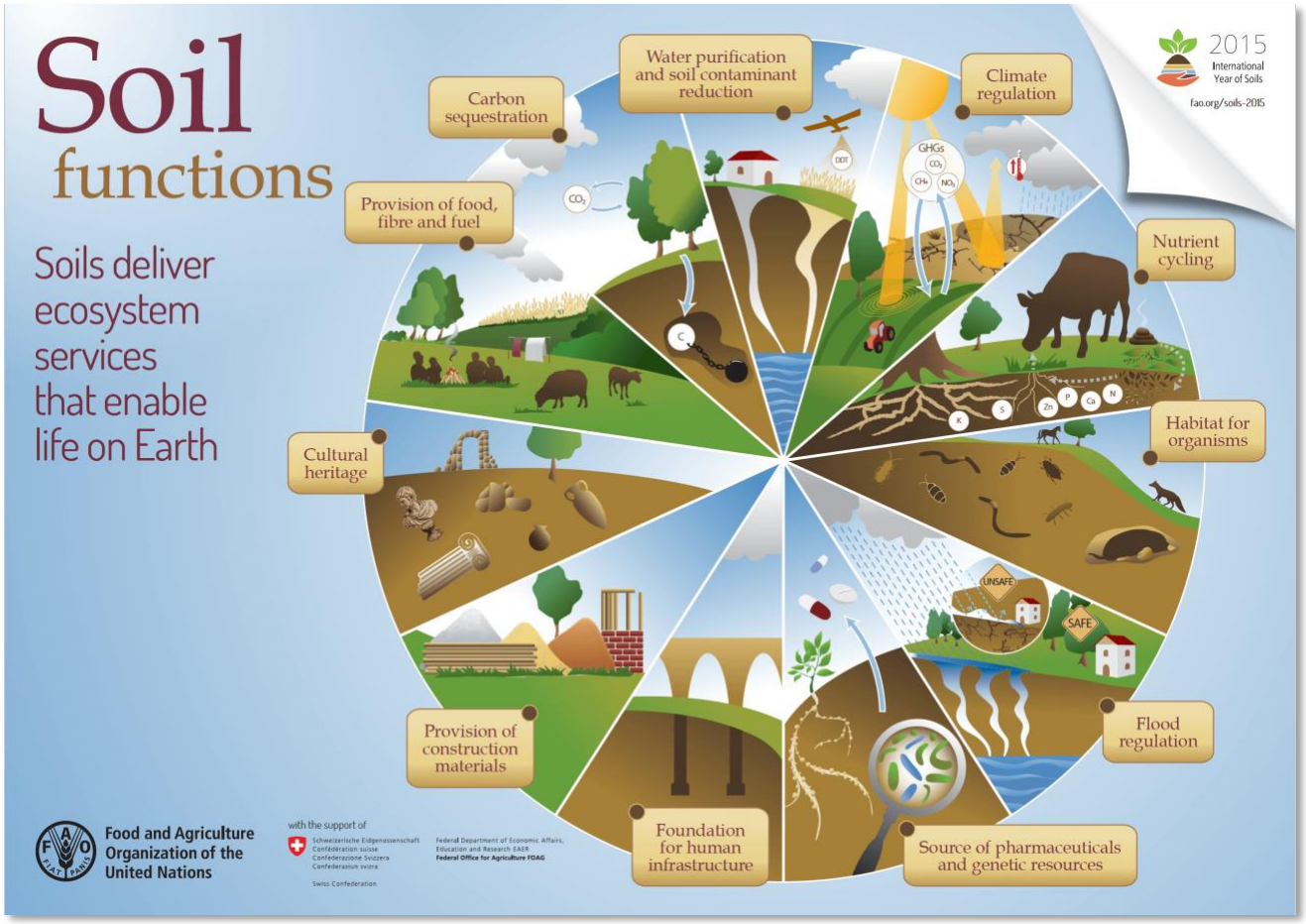
What is healthy soil?

There are more living organisms in a tablespoon of soil than there are people on Earth. One cubic metre of healthy soil can retain over 250 litres of water. Ninety-five percent of our food comes from soils, yet the FAO estimates that 33% of the earth's soils are already degraded and over 90% could become degraded by 2050.[11]

Soils deliver a variety of ecosystem services that enable all—plant, animal, human—life on Earth, including carbon sequestration, nutrient and energy (carbon and organic matter) cycling, water storage and cycling, climate regulation, habitat for organisms, among others as shown in Figure 1.

[11] Food and Agriculture Organization of the United Nations, Global Symposium on Soil Erosion, 2019.

Figure 1 – Soil Functions and Ecosystem Services



Source: Food and Agriculture Organization of the United Nations, "Soil Infographics," Global Soil Partnership, 2015.

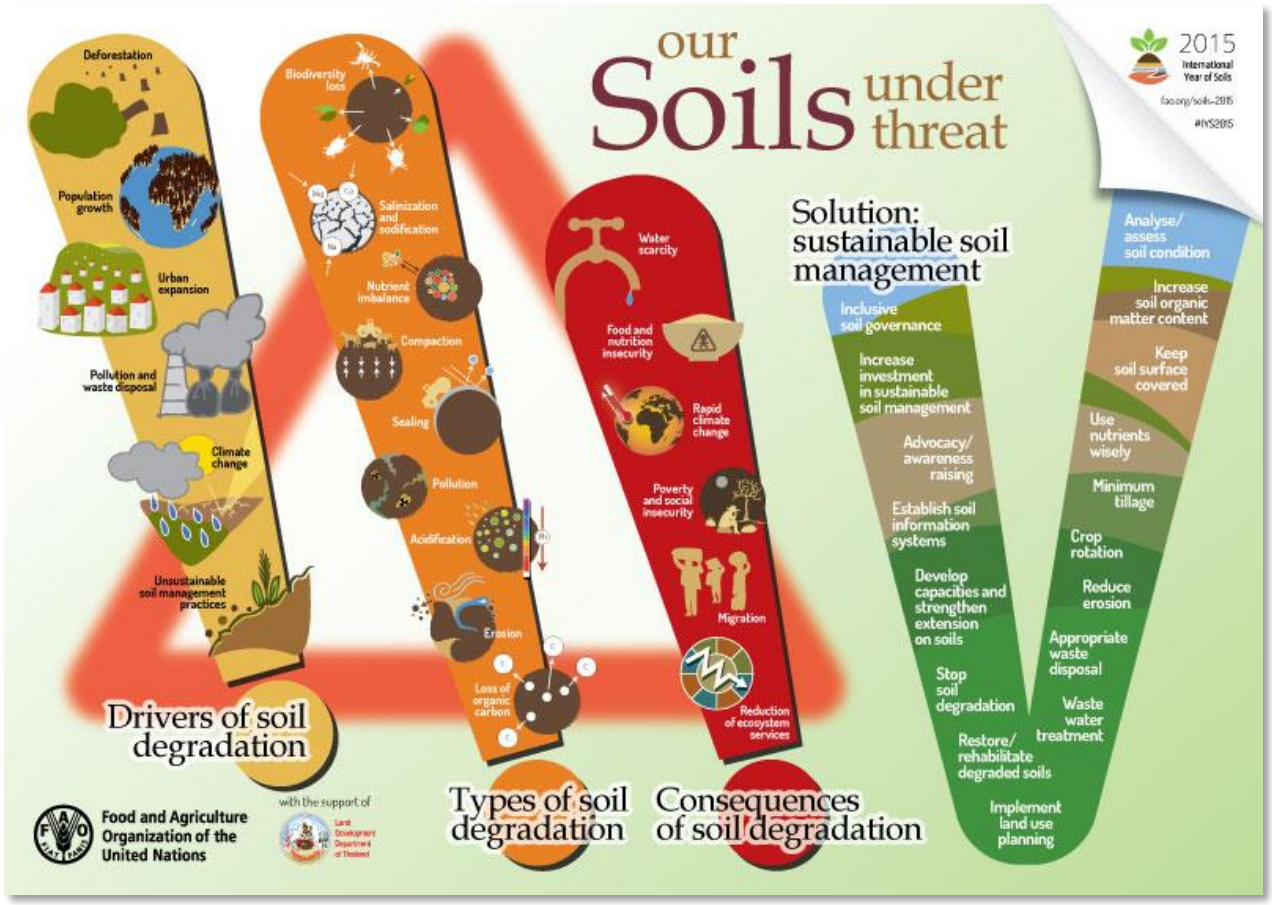
Soil is the foundation of a living ecosystem with dynamic interactions between physical, chemical, and biological properties. The committee learned that soil health is an evolving concept whose definition varies in each sector and requires different management strategies.[12] In agriculture, a healthy soil produces food for people, feed for animals, and fiber and fuel for national and global consumption.[13] The concept, however, does not apply equally to forest soils because ecosystem services do not always work in concert.[14] For example, large areas of peat soils in Northern Canada have high organic matter content, but are not productive in terms of timber yield.[15] The topic of

[12] AGFO, *Evidence*, 7 December 2023 (Derek MacKenzie, Associate Professor, Department of Renewable Resources, University of Alberta, As an individual).
[13] AGFO, *Evidence*, 27 September 2022 (Laura L. Van Eerd, Professor, Sustainable Soil Management, University of Guelph, As an individual).
[14] AGFO, *Evidence*, 25 October 2022 (Sean Thomas, Research Professor, University of Toronto, As an individual).
[15] Ibid.

forest soil health is not often heard of, yet 35% of Canada is covered by forest, representing 9% of the world's forest area.[16]

Soil degradation prevents all soils from providing ecosystem services. It negatively affects the livelihoods of millions of people and poses a serious threat to food security. Figure 2 presents the main drivers, types, and consequences of soil degradation, as well as sustainable soil care and management solutions.

Figure 2 – Drivers, Types and Consequences of Soil Degradation



Source: Food and Agriculture Organization of the United Nations, "Soil Infographics," *Global Soil Partnership*, 2015.

[16] AGFO, *Evidence*, 14 February 2023 (Dominic St-Pierre, Director General, Laurentian Forestry Centre, Natural Resources Canada).

Laura L. Van Eerd, Professor, Sustainable Soil Management, University of Guelph, told the committee the first approach to protect and enhance soil health is to minimize threats to degradation; the second is to adopt practices that build or maintain soil health. Degradation threats must be identified and mitigated and are farm- and field-specific.[17]

Throughout Canada, beneficial soil management, or soil care, practices such as soil compaction reduction, crop and animal diversity, conservation tillage, using compost and amendments, and continuous living plants and cover crops can help build or maintain soil health. However, witnesses told the committee there is no "one-size-fits-all-approach" to soil care practices as soils and climates vary throughout the country.

Senators Rob Black and Pat Duncan participate in an experiment at the University of Guelph's Soil Health Interpretive Centre as part of a fact-finding mission.

Section 95 of the *Constitution Act, 1867* establishes agriculture as a concurrent or shared jurisdiction between the federal government and the provinces. Provinces may enact laws relating to agriculture if they do not contravene federal legislation in the area. In practice, the federal, provincial, and territorial governments negotiate five-year funding agreements—the recent $3.5 billion, five-year Sustainable Canadian Agricultural Partnership (Sustainable CAP)—for cost-shared agricultural initiatives such as business risk management programs for farmers. Collaboration is

[17] AGFO, *Evidence*, 27 September 2022 (Laura L. Van Eerd, Professor, Sustainable Soil Management, University of Guelph, As an individual).

required to make the agriculture and agri-food sector stronger, more powerful, and more responsive to the environmental and economic challenges that farmers, ranchers, growers, and all Canadians face. In its hearings, the committee heard from witnesses representing every province and territory in Canada. Witnesses described:

- the soil conditions and main threats to soil degradation in their regions;
- the valuable work they are doing to improve and protect soils through beneficial soil management practices; and,
- the barriers they face to entry, financing, accessing programs, soils data collection, and technology.

Northern Canada

Climate change frames the context for the state of soil in Canada's northern territories: Yukon, Northwest Territories, and Nunavut.

The committee learned that many northern soils are founded in permafrost. Cryosols—a specifically Canadian order and the dominant soil type throughout most of the territories—are classified by the presence of permafrost in the top two metres of the ground. Christopher Burn, Professor, Chancellor's Professor of Geography, Carleton University, told the committee that "the most pressing soil condition concerns the large amount of carbon that is currently frozen and stored in our Cryosols. […] [T]he effects from thawing of ice in the ground are one of the risks northern farmers assume."[18]

The prospects for agriculture and forestry have increased in the North as a direct result of climate change and settlement of land claims.

> *"I regret to say that Canadian attention to this problem is not what it should be. There is no coordinated national initiative to determine the extent of carbon storage in permafrost, the rate of emissions, the rate of carbon being released from permafrost into thawing ground, the conditions that accelerate such emission or actions that could be taken to mitigate release of carbon from the permafrost soils."*
>
> *Christopher Burn*[19]

[18] AGFO, *Evidence*, 29 September 2022 (Christopher Burn, Chancellor's Professor of Geography, Carleton University, As an individual).
[19] Ibid.

Overall, the committee learned there are regional differences throughout the three territories, yet a significant cost and threat to all three territories is melting permafrost. There is also a significant gap in coordination and representation nationally on these issues.

Yukon

Randy Lamb, Agrologist, Department of Energy, Mines and Resources, Government of Yukon, informed the committee that there are approximately 140 titled farm properties in Yukon: 50% produce a commercial crop and 50% are smaller, subsistence-type operations that "fall below the radar of Statistics Canada."[20]

Historically, Yukon's biggest agricultural sector was hay production; however, Lamb reported that, in the last decade, commercial production of government-inspected red and white meat, graded eggs, vegetable, grains, and berries has increased. Yukon currently produces 4% to 7% of the food it consumes; its agricultural goals focus on food security versus exports. Yukon's transportation system is fragile; washouts and landslides cut off southern supply routes in 2012 and 2022.[21]

While climate change represents challenges, it also represents the opportunity to grow more food in the North. In Yukon, for example, more people are taking up the activity of food production in backyards and community gardens:

> *"Over the last 50 years, the growing season in Whitehorse – in southern Yukon –has increased by one week, and in the last 50 years, it's increased by two weeks in central Yukon. That creates a much greater opportunity to grow additional crops and to have better crop harvests […] Now there are farmers who are reliably maturing wheat and barley crops and producing a commercial flour mill with retail products."*
>
> *Randy Lamb*[22]

Lamb said that Yukon's agricultural soils "are relatively young and undeveloped throughout most of the territory. The last ice sheets retreated from southern Yukon about 10,000 years ago, except the unglaciated areas near Dawson City and northwards, in the north-central area known as Beringia. Generally, soils in southern Yukon are dryer, slightly alkaline silty loams with very low organic

[20] AGFO, *Evidence*, 23 March 2023 (Randy Lamb, Agrologist, Department of Energy, Mines and Resources, Government of Yukon).
[21] Ibid.
[22] Ibid.

matter. In the central Yukon region near Dawson City, soils are wetter, more acidic and have higher levels of organic matter."[23]

Brandon Drost, Forester, Department of Energy, Mines and Resources, Government of Yukon, said that forest soil health is also important to Yukon. "The Yukon makes up about 8% of the boreal forest in Canada. It holds approximately 5.5 billion tons of carbon," said Drost.[24] Forest soils are the foundation of this forest, which supports the local forest industry and provides ecosystem services for the local population, as well as others around the world.

There is an interchange between forestry and agricultural land in Yukon, especially in the valleys. Drost explained that Yukon is currently dealing with water, landslide, and erosion issues likely due to changes in climate, which impact soil health. Permafrost changes, in both agricultural and forest soils, may release more carbon and soil stability will decrease. "There may be impacts to above-ground forest resources, including those ecosystem services that we rely on."[25]

The main threats to soil function and productivity in Yukon are cold soils, lack of soil organic matter (2 to 5% average), short growing seasons, and intermittent permafrost towards the north. "Soil health in Yukon depends on the living organisms in soil that include limited amounts of microflora and microfauna as compared to southern soils," which Lamb said requires help from federal partners at Agriculture and Agri-Food Canada (AAFC). [26]

The Government of Yukon's projects are now starting to consider soil health including a three-year marginal crop trial with AAFC's research centre in Newfoundland and Labrador. Yukon has also started the third year of a farm-scale mulching trial near Whitehorse, which includes an annual sampling program of soil fungi from the forested stage through to field crop stages: "Mycorrhizal species are a key component of soil health in the boreal forest where our agriculture is developed," noted Lamb.[27] The project involves soil sampling assistance by Yukon University and microbiological analyses by AAFC, otherwise Lamb said, "we would not be able to carry out mycorrhizal research on our own."[28]

The committee learned that First Nations are focusing on regenerative agriculture and organic agriculture, even though they are not certified, said Lamb. Of the seven or eight First Nations that Lamb had recently visited, they all had the common interest of farming or gardening naturally and switching from synthetic pesticides and instead to organic practices. "That's fully embraced," said

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[23] Ibid.
[24] AGFO, *Evidence*, 23 March 2023 (Brandon Drost, Forester, Department of Energy, Mines and Resources, Government of Yukon).
[25] Ibid.
[26] AGFO, *Evidence*, 23 March 2023 (Randy Lamb, Agrologist, Department of Energy, Mines and Resources, Government of Yukon).
[27] Ibid.
[28] Ibid.

Lamb, "and we're providing soil testing to them, encouraging them and providing smaller amounts of funding for projects through our five-year funding programs to help these activities."[29]

Regarding forestry, Drost said there is not a good understanding of the current forest soil health conditions across the Yukon. "There's a lack of data and we don't have a good database of soil records. We need a reliable baseline and monitoring data to ensure evidence-based decisions are made for sustainable forest management."[30]

Currently, Yukon follows sustainable forest management practices and has soil conservation standards and guidelines for minimizing disturbance to forest soils during harvesting of timber.

Drost said: "We are collaborating with the Canadian Forest Service to deliver the National Forest Inventory program. Under this program, soils are analyzed to determine soil carbon and carbon change over time. This data is used to support various projects, such as developing soil carbon accounting models, climate change-related soil studies, soil mapping, remote sensing and supporting other forest research projects that have a soil health component."[31]

Northwest Territories

Janet Dean, Executive Director, Territorial Agrifood Association, informed the committee that the Northwest Territories has an active land-based agriculture sector that requires constant soil management. A variety of soil types are found on the regional scale; the best soil for agriculture is in southern areas of the Taiga Plains and ecoregions in the southern and northwest parts of the territory. Soil requires amendments, such as manure, but Dean said amending the soil is costly.[32]

[29] Ibid.
[30] AGFO, *Evidence*, 23 March 2023 (Brandon Drost, Forester, Department of Energy, Mines and Resources, Government of Yukon).
[31] Ibid.
[32] AGFO, *Evidence*, 23 March 2023 (Janet Dean, Executive Director, Territorial Agrifood Association).

Vegetables grow inside a greenhouse in Inuvik, Northwest Territories.

Remote communities are impacted by limited access to good soil for food production, particularly the Tłı̨chǫ communities in the Canadian Shield geologic region. Dean said the soil there is thin and low in essential nutrients. This region also experiences food insecurity; 55% of residents are food insecure.[33]

The committee learned Paradise Valley is the most fertile and accessible private land in the Northwest Territories. According to Dean, "it is an asset that must be protected" because of its agricultural potential. In 2022, a devastating flood damaged most of the valley's farms. When farmers leave, there is no restriction on conversion of farmland. Dean reported that the flood ceased operations in seven of the eight titled farms in that region.[34]

[33] Ibid.
[34] Ibid.

> *"The Northwest Territories stores a lot of soil carbon and the conversion of boreal forest to agricultural land for greater food production has the potential to result in large carbon losses to the atmosphere, impacting climate change. Soil carbon and soil fertility for agriculture are inversely related in southern Northwest Territory soils."*
>
> *Janet Dean*[35]

Dean explained that areas with lots of soil carbon are potentially less suited for crop production than areas with less soil carbon. Dean said this has implications for land management decisions in that areas with high fertility and low soil carbon for agricultural land use could be targeted. This could limit the magnitude of carbon losses due to agriculture. However, there is little private land available in these areas and there are no agricultural reserves in the Northwest Territories: 95% of farming happens within municipal boundaries.[36]

Dean told the committee that a recent University of Guelph research project evaluated how effective commonly used Northwest Territories agricultural soil management practices were at improving soil fertility and soil carbon stocks. The results showed that no-till sites and sites that used compost improved soil fertility. No-till sites also improved soil carbon stocks. The study compared sites that were currently used for agriculture to sites that were once cultivated, but now abandoned. The study found that soil fertility in abandoned agricultural sites increased over time since abandonment while soil fertility in actively farmed sites declined over time since cultivation. Dean said this highlights that current agricultural management practices are not effective at building fertile soils in the Northwest Territories, and that innovative means are necessary.[37]

Dean requested more research on agricultural management practices, and a focus on partnering with farmers and Indigenous communities of the Northwest Territories to develop practices targeted to the North, as well as sequestering carbon.

As for forestry, Mike Gravel, Director, Forest Management, Northwest Territories Environment and Climate Change, Government of the Northwest Territories, told the committee that the territory does not have an intensive forestry sector. The government's focus is instead to minimize any impact on forest soils such as ensuring minimal compaction while forest activities take place. Forest

[35] Ibid.
[36] Ibid.
[37] Ibid.

activities take place during the winter while the ground is frozen thereby causing minimal disturbance.[38]

Gravel said that the emerging issue in recent years is permafrost thawing and slumping. The territorial government is focused on drought conditions of the soil for impacts on fire, as 2023 brought the worst fire season and droughts ever in the Northwest Territories.[39]

Gravel said there is no dedicated staff to monitor soils from a forest perspective in Northwest Territories. Gravel stressed the importance of understanding the effects of drought and the recovery from drought—for example, how much moisture-specific soils may need to recover—understanding soil stability with respect to the changing climate and as northern soils warm, as well as understanding the impact this has on permafrost and on soil productivity in general.

> *"We have over 80 million hectares of forest. We have a large land base to cover and a very small team of forest professionals to manage that land base. Remote technology that could support soil mapping with respect to productivity, potential productivity, or forest health would be beneficial."*
>
> *Mike Gravel*[40]

Nunavut

Michelle Blade, Permafrost Scientist, Government of Nunavut and member of the Canadian Permafrost Association, informed the committee that agriculture and forestry are "southern terms" that describe a "southern relationship with the land" and do not necessarily apply in Nunavut.

[38] AGFO, *Evidence*, 30 November 2023 (Mike Gravel, Director, Forest Management, Northwest Territories Environment and Climate Change, Government of the Northwest Territories).
[39] Ibid.
[40] Ibid.

> *"In Nunavut, we harvest a relationship with the land defined in the Nunavut Agreement forming the territory of Nunavut. Harvesting in Nunavut is equally if not more so dependent on soil health considering Nunavut has the highest rate of food insecurity of any province or territory in Canada."*
>
> *Michelle Blade*[41]

Twenty-five percent of Nunavummiut (Inuktitut word for 'inhabitants of Nunavut') are severely food insecure, yet Blade reported that Nunavut is food abundant: "Inuit over generations have developed unique tools and technologies for a sovereign food system by harvesting caribou, Arctic char, berries, birds, and marine mammals. For many Inuit, winter represents an important time of year to harvest, along with the summer, with no need for in-territory agriculture or animal husbandry."[42]

The committee learned that long-range atmospheric transport of contaminants from around the globe is impacting Nunavut's soil health. This has resulted in bioaccumulation and magnification of heavy metals, plastics and organic pollutants in harvested foods and soils. Blade reported that harvested food is tested in collaboration with hunters. Most contaminants found in marine mammals are not found in caribou, yet health advisories limit the consumption of caribou livers and kidneys due to the presence of mercury, which has been linked to neurodevelopmental problems, especially in fetuses and young children. Blade noted that one of the research priorities of the Government of Canada's Northern Contaminants Program is to better understand the biogeochemical mercury cycle in Arctic soils. [43]

The committee also heard that climate change is impacting harvesting in Nunavut. Blade explained all of Nunavut is underlain by permafrost and each summer, the top portion of the soil profile thaws and refreezes the following winter. This seasonal thaw depth is expected to increase by three to five metres throughout much of Nunavut within the next 50 years.[44]

Blade told the committee that Nunavut would benefit from:

- the collection and analysis of Nunavummiut observations to understand how and to what degree permafrost change impacts are affecting Nunavut soil health and food sovereignty; and

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[41] AGFO, *Evidence*, 23 March 2023 (Michelle Blade, Permafrost Scientist, Nunavut, Canadian Permafrost Association).
[42] Ibid.
[43] Ibid.
[44] Ibid.

- a territorial permafrost assessment program to analyze and predict how quickly soil health will change, and what impacts are more likely to occur near one Nunavut community compared to another.[45]

According to Blade, frozen land and soil assessments often fall between government jurisdictions in Nunavut. For example, Crown-Indigenous Relations and Northern Affairs Canada has a Nunavut water quality monitoring program; however, Blade said the program does not assess permafrost, even though permafrost directly controls how water flows on and through Nunavut land and soils.[46]

Blade stated, "surficial geology in Northwest Territories and Yukon is more sediment rich than it is in Nunavut." Most permafrost work in academia—including Dr. Burn's—and government, occurs in the Northwest Territories and Yukon, and not in Nunavut. "It speaks to a discrepancy in funding and research priorities between the western Arctic and the eastern Arctic." [47] Blade emphasized the need for research in Nunavut, as well as pan-territorial collaboration.

Western Canada

British Columbia

The committee learned that British Columbia is home to diverse soil types and soil zones. Agriculture is one of the biggest economic drivers in the province—comprising 5% of the total land base as set out in the Agricultural Land Reserve—and is important to local rural and Indigenous economies.[48] Agriculture systems, though small, are productive and diverse, and face increasing pressures from urbanization. British Columbia has more than 200 commodities. According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for British Columbia were: dairy ($701 million), vegetables ($633 million), and floriculture, nursery and sod ($543 million).[49]

[45] Ibid.
[46] Ibid.
[47] Ibid.
[48] The Agricultural Land Reserve is British Columbia's provincial zone that preserves agricultural land for the future.
[49] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.

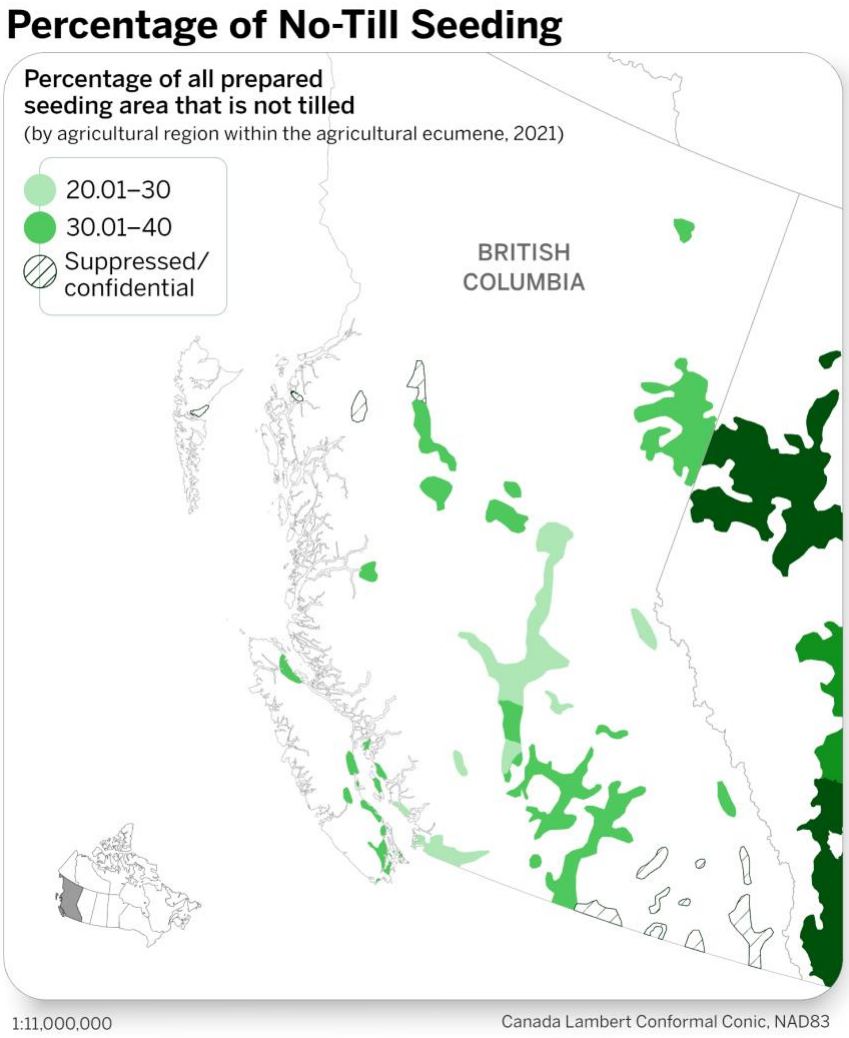
Apple trees line an orchard at the Mission Hill Family Estate Winery in West Kelowna, British Columbia.

Mark Raymond, Executive Director, Extension and Support Services Branch, British Columbia Ministry of Agriculture and Food, Government of British Columbia, told the committee that recent extreme weather events—flooding, wildfires, drought, and extreme heat—have severely disrupted and, in some cases, devastated local food production.[50]

According to the 2021 Census of Agriculture, no-till has been adopted up to 30% in British Columbia, as shown in Figure 3. The percentage of hectares prepared for no-till is calculated by agricultural region within the agricultural ecumene from the 2021 Census of Agriculture.[51]

[50] AGFO, *Evidence*, 30 March 2023 (Mark Raymond, Executive Director, Extension and Support Services Branch, British Columbia Ministry of Agriculture and Food, Government of British Columbia).
[51] The term "ecumene" refers to the geographic areas where Canada's main agricultural activities take place.

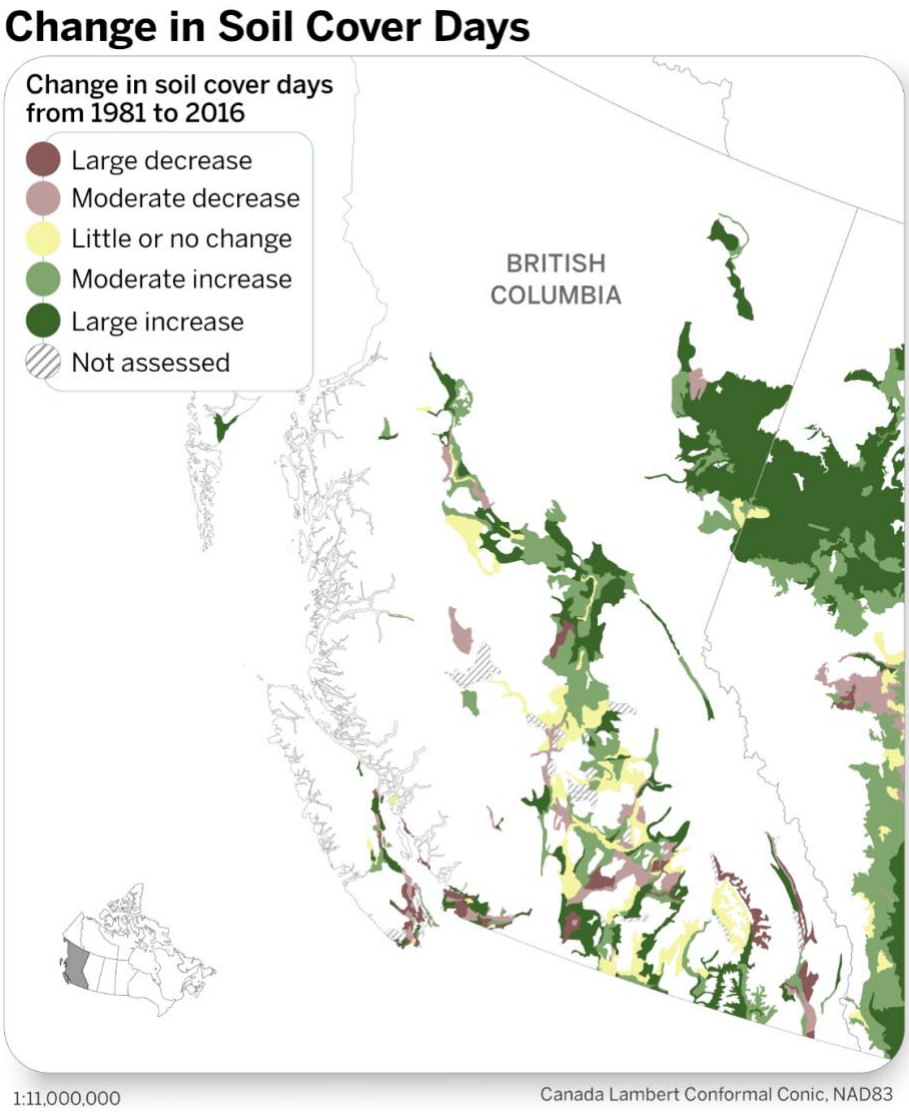
Figure 3 – Percentage of Hectares Prepared for No-Till Seeding: British Columbia (2021)



Sources: Map prepared in 2024 using data obtained from Statistics Canada, "Table 32-10-0367-01: Tillage and seeding practices, Census of Agriculture, 2021," Database, accessed 28 November 2023; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Statistics Canada Open Licence*.

According to AAFC's Agri-Environmental Indicator – Soil Cover Days dataset, from 1981 to 2016, the amount of time that agricultural soils were covered by a crop, crop residues, or snow increased in central and northern areas of the province, as shown in Figure 4. There is a patchwork of changes across the agricultural lands. Few areas exhibit decreases in soil cover days.

Figure 4 – Change in Soil Cover Days: British Columbia (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Cover Days*, 16 December 2020; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence.*

The committee heard that the main causes of soil degradation in British Columbia are soil compaction, soil salinization and its impact on irrigation water, loss of soil organic carbon and water retention in soils, soil erosion, and run-off (debris) from wildfires.

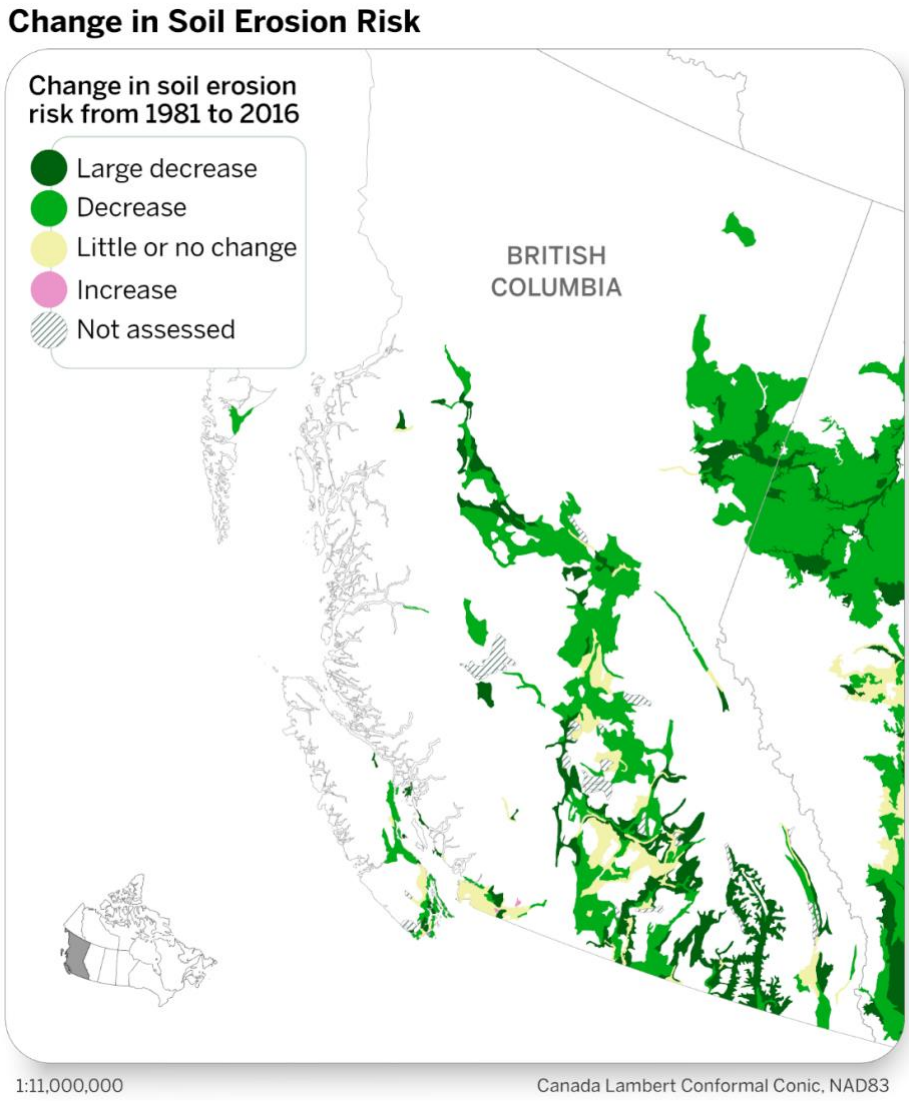
Dieter Geesing, Provincial Soil Specialist, British Columbia Ministry of Agriculture and Food, Government of British Columbia, explained that soil degradation happens differently throughout the province's diverse landscapes and climate. For example, along the coast, "prolonged periods of high water tables reduce the time that farmers can work their fields, making soils more vulnerable

to compaction. In the fertile delta of the Fraser River ocean waters are moving further and further upstream, impacting irrigation and soil salinity. In rural crops like blueberries, soil erosion is expected to increase because of more intense precipitation."[52]

The map in Figure 5 illustrates the change in estimated risk of soil erosion from the combined effects of wind, water, and tillage for agricultural areas in British Columbia from 1981 to 2016. Large decreases in soil erosion risk appear in and to the east of the Okanagan Valley.

[52] AGFO, *Evidence*, 30 March 2023 (Dieter Geesing, Provincial Soil Specialist, British Columbia Ministry of Agriculture and Food, Government of British Columbia).

Figure 5 – Change in Estimated Risk of Soil Erosion: British Columbia (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Risk of Soil Erosion*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Paul Pryce, Director of Policy, B.C. Agriculture Council, added that because of rising sea levels in the city of Delta in the Lower Mainland region—an important area of agriculture production for the province—there is an increased risk of soil salinity, as well as reduced access to irrigation water during the typical growing season."[53]

[53] AGFO, *Evidence*, 4 May 2023 (Paul Pryce, Director of Policy, BC Agriculture Council).

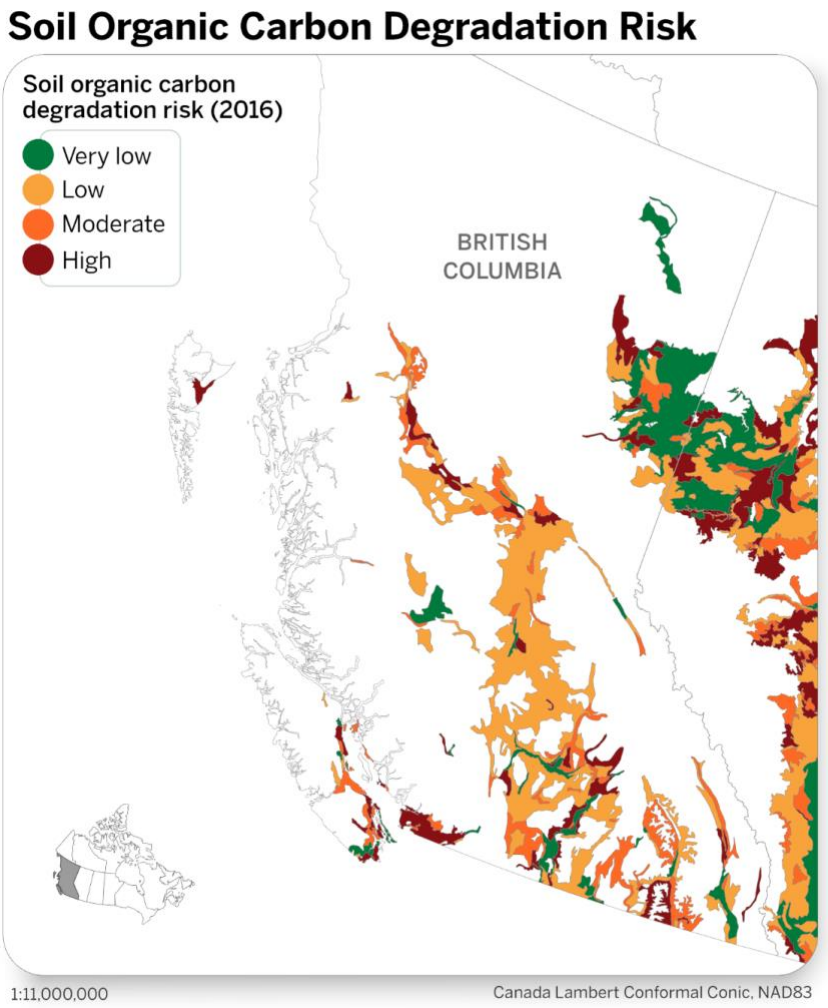
The other major concern is the loss of soil organic carbon. Sean Smukler, Associate Professor, Applied Biology and Soil Science, University of British Columbia, told the committee that his research lab had recently published an analysis of the trajectory of soil health in the province:

> *"Using sampling and a modelling approach, we showed that from 1984 to 2018, in one of the most intensive agricultural landscapes in the province, there was an alarming decrease in soil organic matter across 61% of the landscape."*
>
> *Sean Smukler*[54]

Figure 6 shows that, in 2016, most agricultural areas in British Columbia exhibited low or moderate levels of risk of soil organic carbon degradation.

[54] AGFO, *Evidence*, 29 September 2022 (Sean Smukler, Associate Professor, Applied Biology and Soil Science, University of British Columbia, As an individual).

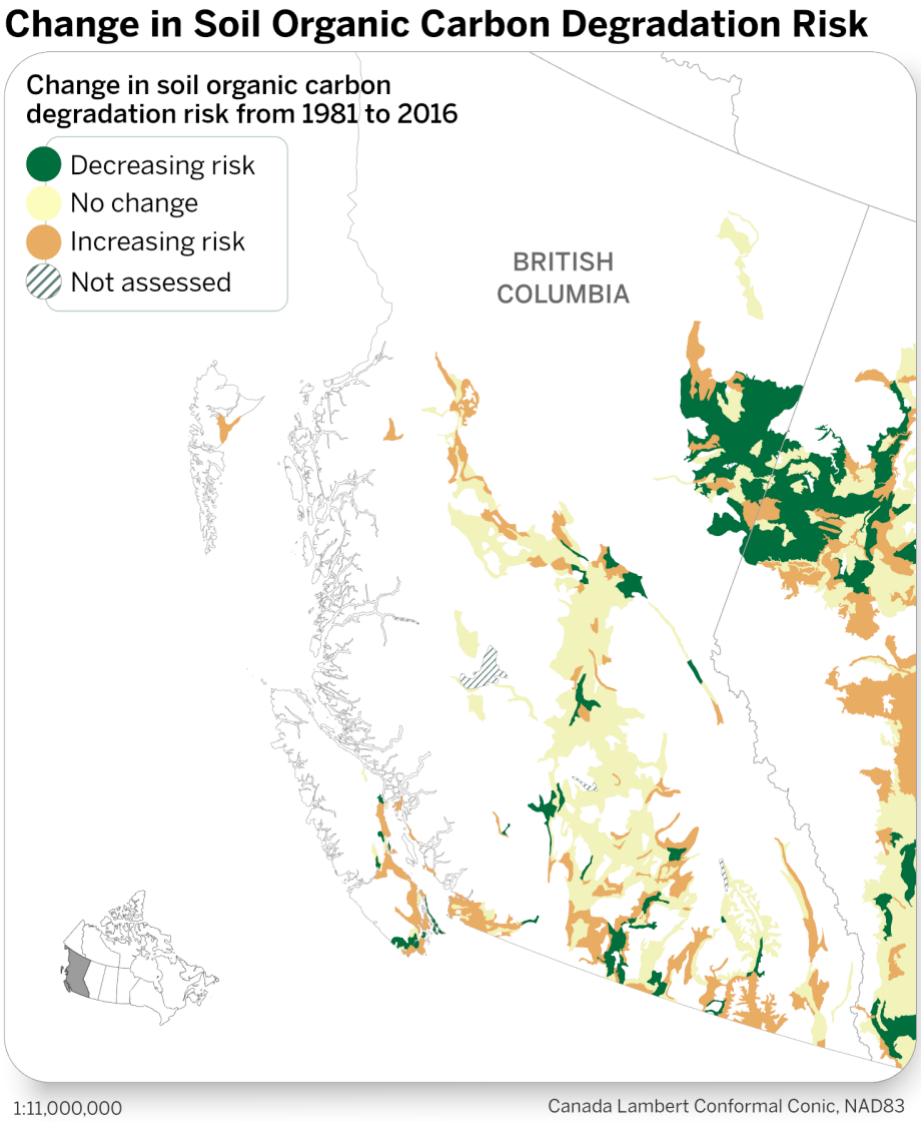
Figure 6 – Soil Organic Carbon Degradation Risk: British Columbia (2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

As for the change in risk of soil organic carbon degradation over time, Figure 7 shows that the northeast region of the province and parts of the Okanagan Valley as having decreased risk from 1981 to 2016. No change is noted in the central regions while some increasing risk can be seen along the east coast of Vancouver Island, the southwest mainland, and parts of the Kootenays.

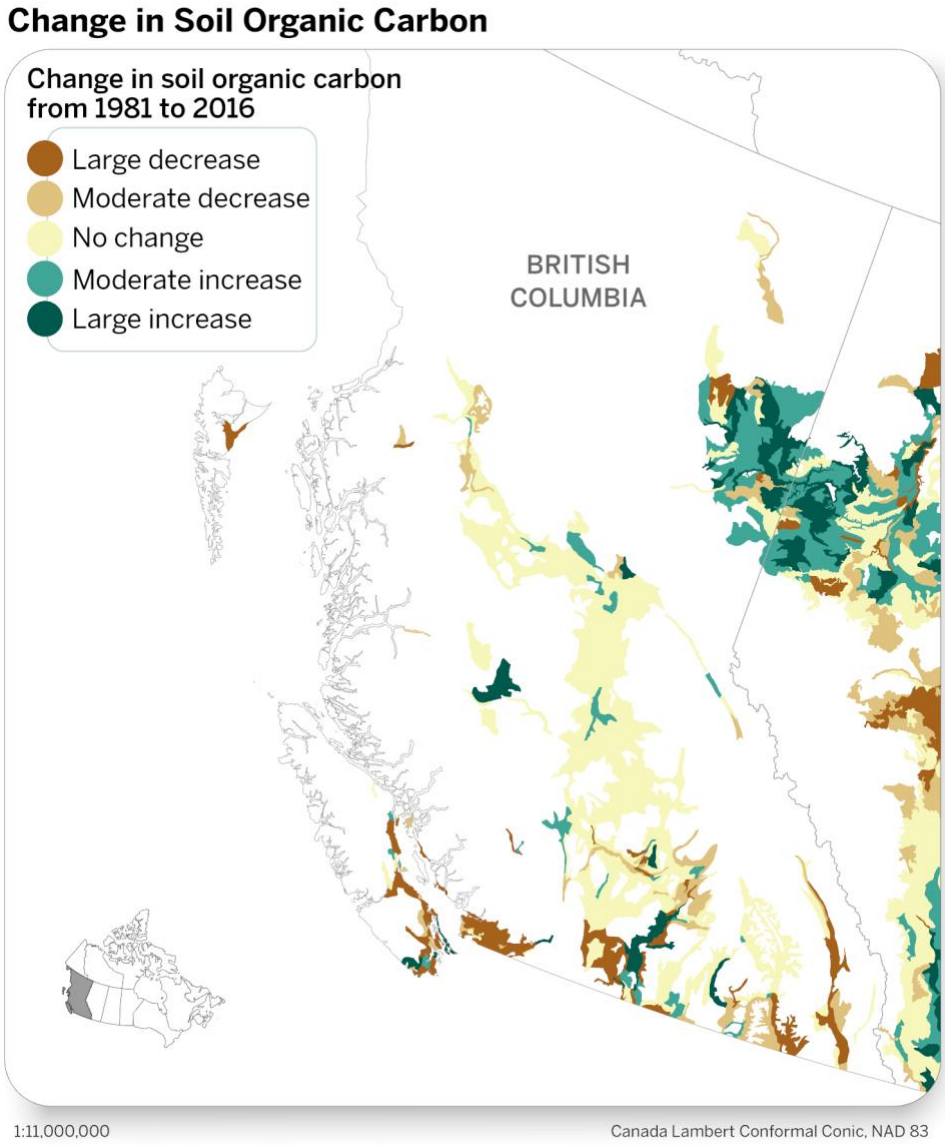
Figure 7 – Change in Soil Organic Carbon Degradation Risk: British Columbia (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

The map in Figure 8 illustrates the change over time of the estimated amount of CO_2 that has been removed from the atmosphere and sequestered as soil organic carbon in British Columbia's agricultural soils. A patchwork of changes has occurred from 1981 to 2016 with areas of no change across central British Columbia. Decreases appear in the south while increases appear in the northeast.

Figure 8 – Estimated Change in Soil Organic Carbon: British Columbia (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Runoff from wildfires and other natural disasters can also have an impact on soil health. For example, Pryce explained if macronutrients from a wildfire enter a river, and a farmer who lives downstream of that river and sources some of the water from it for their operation, that will affect

soil health. "Aerosolized debris from a wildfire can carry these macronutrients far and wide, so you don't even need to be downstream to experience these adverse effects."[55]

To improve soil health and soil care practices throughout the province, the Minister of Agriculture's Advisory Group on Regenerative Agriculture and Agritech was formed in 2022 to provide strategic advice to government on opportunities for innovation, technology, adoption, and sustainable practices to create more resilient farms and food systems. Soil health and a resilient food system are two main priorities of B.C.'s Ministry of Agriculture and Food.

The committee heard the Ministry of Agriculture and Food and the Ministry of Forests have been collaborating on soil health and soil carbon, specifically on the soil health of the forestry sector and how that impacts water infiltration and its downstream effects on agriculture and irrigation levels, as well as fish and aquaculture habitats. "It is a very integrated system and we are working closely together on that," said Mark Raymond.[56]

Cindy Prescott, Professor, Department of Forest and Conservation Science, University of British Columbia, told the committee: "The importance of soil biota and carbon inputs from living roots in building healthy soils has been recognized in agriculture and has spurred the rapid development of regenerative agriculture. No such recognition has happened in forestry, despite evidence that carbon inputs from living roots are just as important for soil health in forest ecosystems."[57]

Indigenous participation in agriculture has been an increasing priority for the ministry. Within the B.C. Government's Soil Health Working Group, an Indigenous Advisory Committee was created.

[55] AGFO, *Evidence*, 4 May 2023 (Paul Pryce, Director of Policy, BC Agriculture Council).
[56] AGFO, *Evidence*, 30 March 2023 (Mark Raymond, Executive Director, Extension and Support Services Branch, British Columbia Ministry of Agriculture and Food, Government of British Columbia).
[57] AGFO, *Evidence*, 25 October 2022 (Cindy Prescott, Professor, Department of Forest Conservation Science, University of British Columbia, As an individual).

Despite these efforts, Jacob Beaton, Owner of Tea Creek Training and Employment, an award-winning Indigenous-led training farm and food sovereignty movement in Gitxsan Territory on the northwestern coast of British Columbia, told the committee that Indigenous farmers face ongoing financial barriers:

> *"We heard that 80% of the world's biodiversity rests in Indigenous-controlled lands, which is 20% of the world's landmass. Indigenous peoples are currently contributing to 32% of the world's climate goals on less than 1% of financial resources. One farm loan from Farm Credit Canada has been given to an Indigenous farmer in B.C. ever, so financial resources are a huge barrier for us."*
>
> *Jacob Beaton*[58]

Regarding other barriers, Paul Pyrce underscored the need for updated soil mapping. "In B.C., the most recent soil mapping was completed around 1980. The Government of British Columbia's current manual on land capability classification for agriculture was published 40 years ago this April. As an aside, you can find that manual online, but it's not a searchable PDF."[59]

Pryce added that today, only about 3% of the total land in B.C. is used for agriculture: "There are many factors that likely contribute to this gap — not least of all the sheer cost of land in B.C. Soil maps could help find out why."[60]

The Prairies

The Prairies—Alberta, Saskatchewan, and Manitoba—are home to 80% of Canada's farmland. The region was once also home to vast expanses of native grasslands. The Northern Great Plains are now one of the world's most threatened ecosystems. The Nature Conservancy of Canada estimates that more than 80% of Canada's prairie grasslands have been lost to cultivation, urbanization, and industrial development.[61]

According to Statistics Canada, no-till has been adopted throughout the Prairies at rates between 40% and 75% of cropland hectares prepared for seeding in Alberta, greater than 75% in most of Saskatchewan and up to 90% in some regions of the province, and between 40 to 50% in

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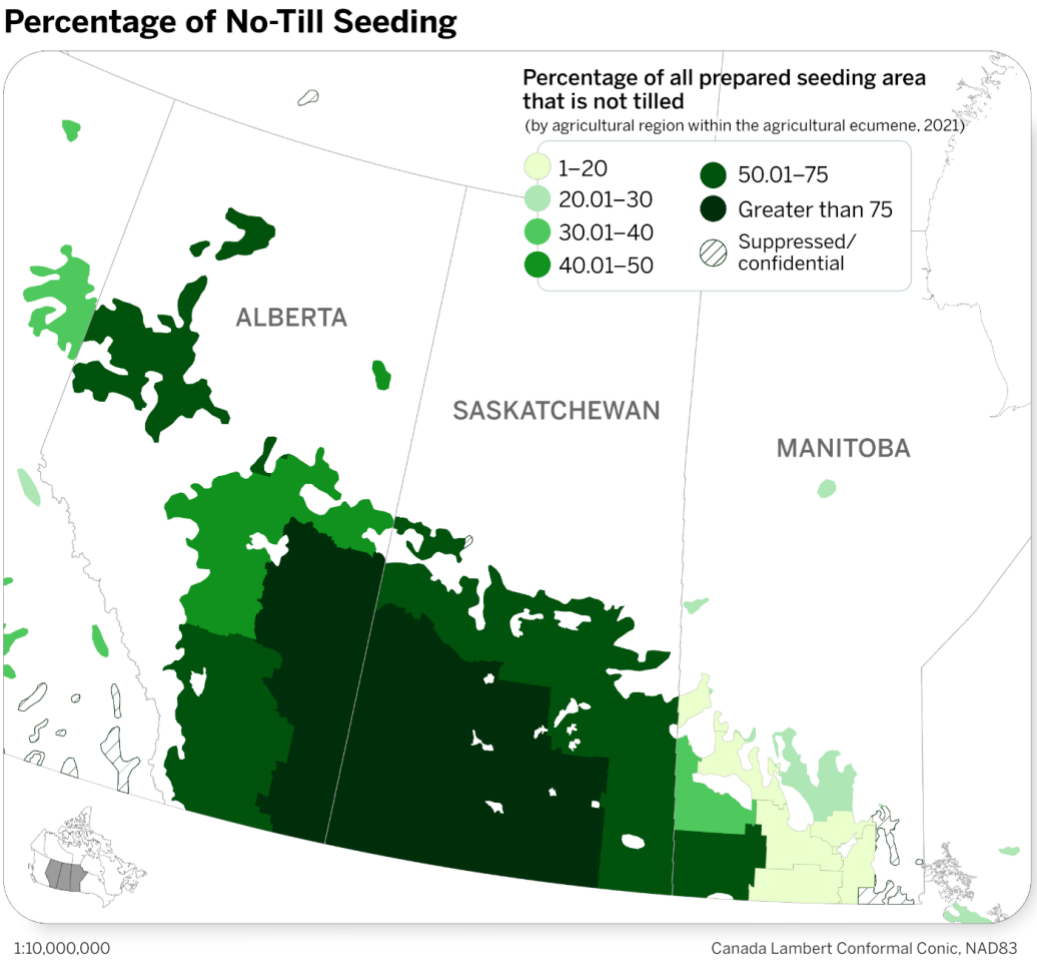
[58] AGFO, *Evidence*, 9 February 2023 (Jacob Beaton, Owner, Tea Creek Training and Employment).
[59] AGFO, *Evidence*, 4 May 2023 (Paul Pryce, Director of Policy, BC Agriculture Council).
[60] Ibid.
[61] AGFO, *Evidence*, 23 November 2023 (Reynold Bergen, Science Director, Beef Cattle Research Council, Canadian Cattle Association); *Evidence*, 13 February 2024 (Melanie Bos, Agriculture Policy Manager, Nature Conservancy of Canada).

southwestern Manitoba, as illustrated in Figure 9 for 2021. David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, summed up this approach: "Diversify our rotations and reduce our disturbance. That's one of the things that Western Canada has succeeded in doing. That helps the soil retain that organic matter."[62] However, some witnesses cautioned the committee that no-till practices in the Prairies were moving backwards and that more acres are reverting to tillage.[63]

[62] AGFO, *Evidence*, 20 October 2022 (David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, As an individual).
[63] AGFO, *Evidence*, 22 September 2022 (Cedric Macleod, Executive Director, Canadian Forage and Grassland Association); and *Evidence*, 27 September 2022 (David Lobb, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba, As an individual).

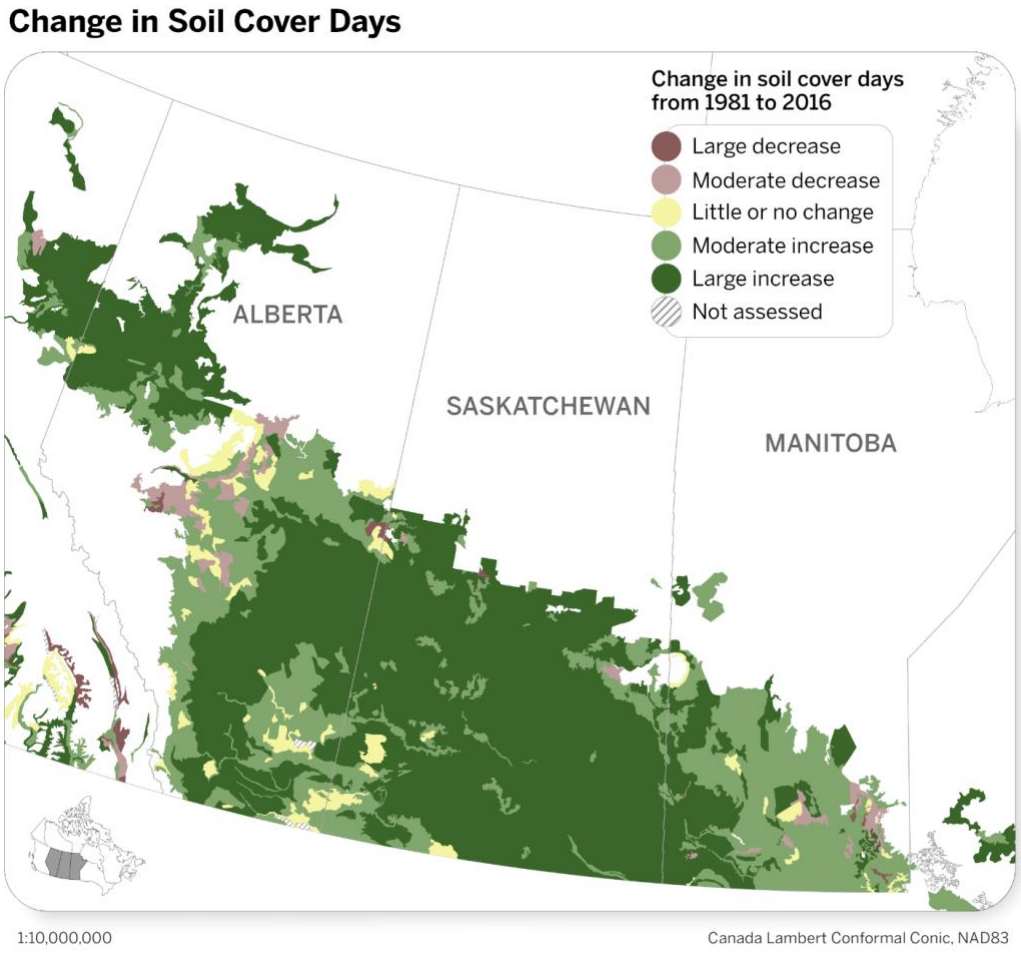
Figure 9 - Percentage of Hectares Prepared For No-Till Seeding: Prairies (2021)



Sources: Map prepared in 2024 using data obtained from Statistics Canada, "Table 32-10-0367-01: Tillage and seeding practices, Census of Agriculture, 2021," Database, accessed 28 November 2023; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Statistics Canada Open Licence*.

The map in Figure 10 illustrates the change in soil cover days for the Prairies from 1981 to 2016. Many agricultural areas in Alberta and Saskatchewan exhibit large increases, whereas Manitoba exhibited moderate increases in soil cover days.

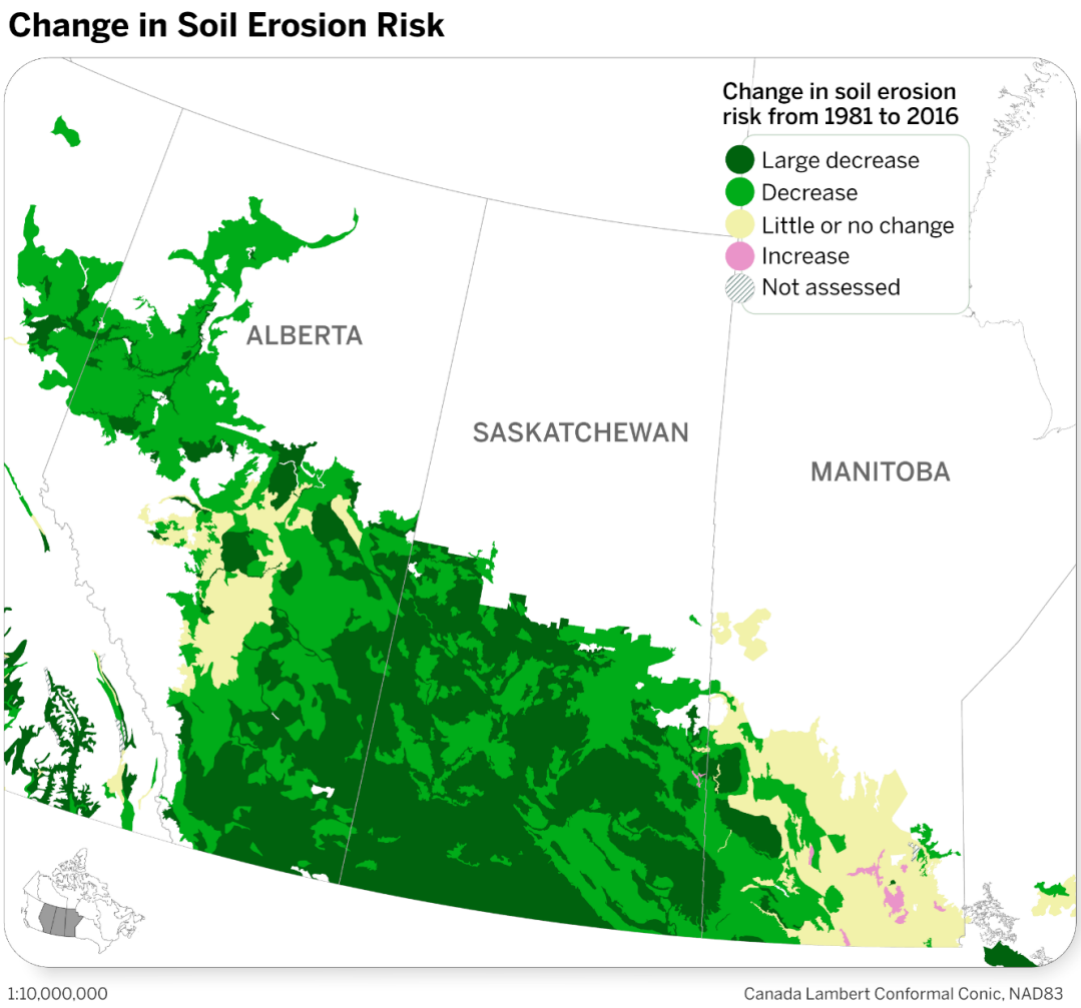
Figure 10 – Change in Soil Cover Days: Prairies (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Cover Days*, 16 December 2020; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

From 1981 to 2016, large decreases in soil erosion risk appeared in southern Alberta and Saskatchewan, with little or no change in southern Manitoba, and mostly a decrease in all other areas, as shown in Figure 11.

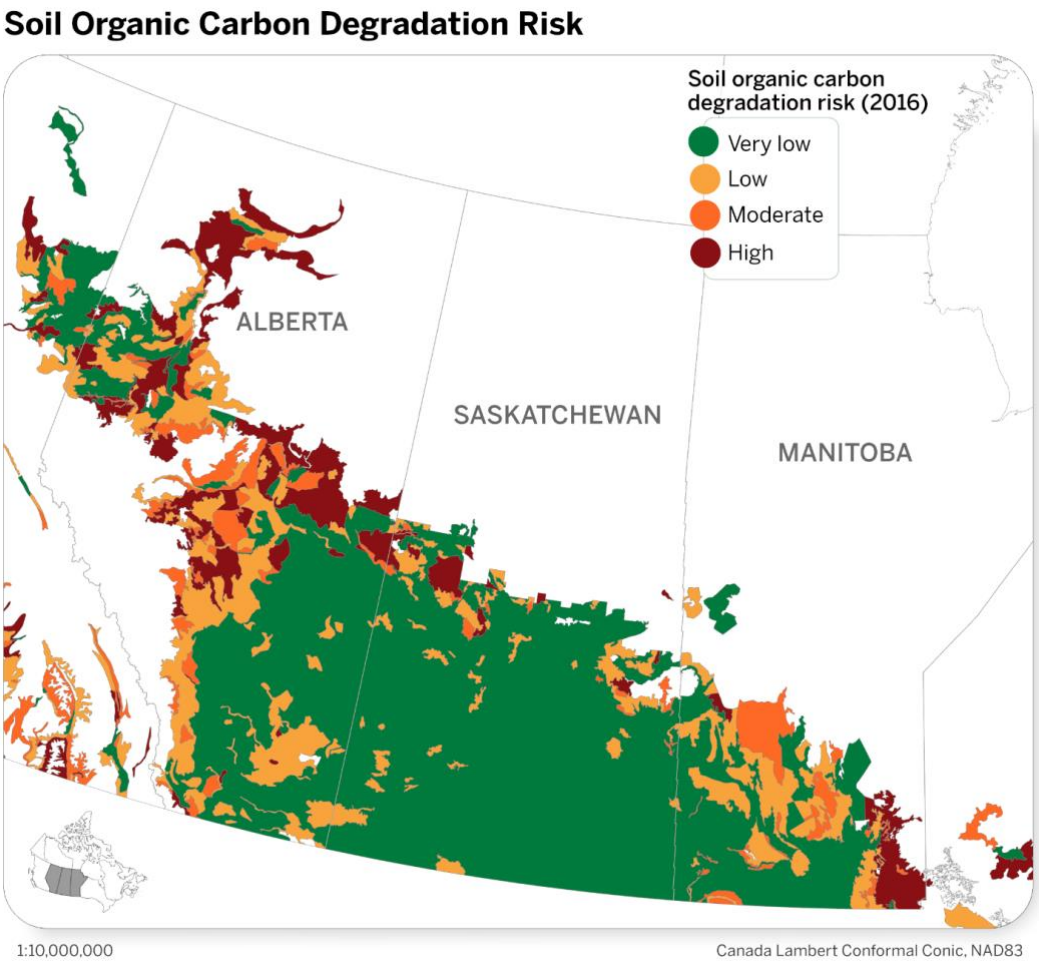
Figure 11 – Change in Estimated Risk of Soil Erosion: Prairies (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Risk of Soil Erosion*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

As mentioned by several witnesses, no-till stops soil degradation from decreasing soil health and also increases soil organic carbon. Figure 12 presents the estimated risk of soil organic carbon degradation for the Prairies in 2016. Areas in northern Alberta and eastern Manitoba appear to be at highest risk while southeastern Alberta, south-central Saskatchewan and southwestern Manitoba were at lowest risk.

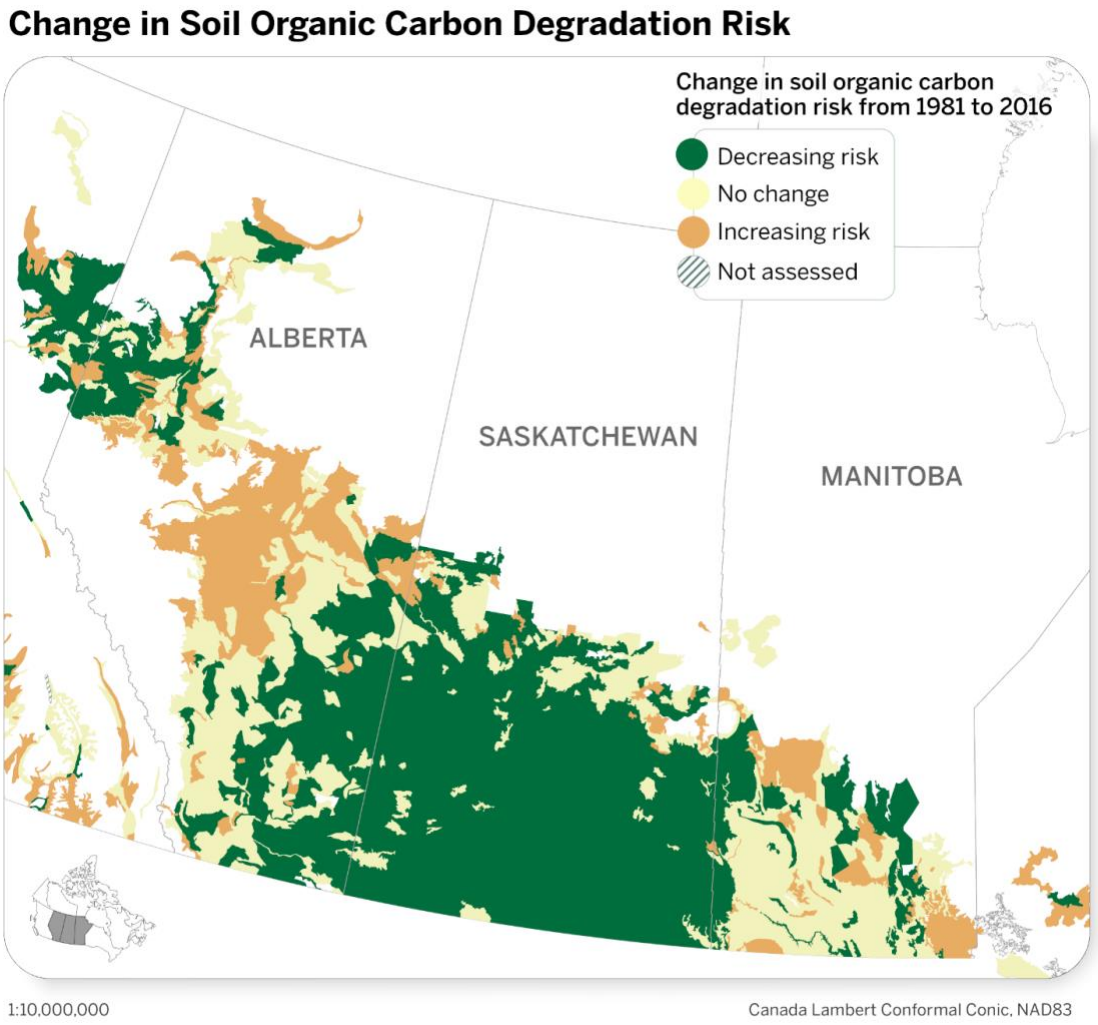
Figure 12 – Soil Organic Carbon Degradation Risk: Prairies (2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

With respect to the estimated change in the overall level of risk of soil organic carbon degradation from 1981 to 2016, a large swath of southern Alberta and Saskatchewan, as well as northwestern Alberta, were classified as having decreasing risk, southern Manitoba as mostly experiencing no change and central Alberta as having some increasing risk, as shown in Figure 13.

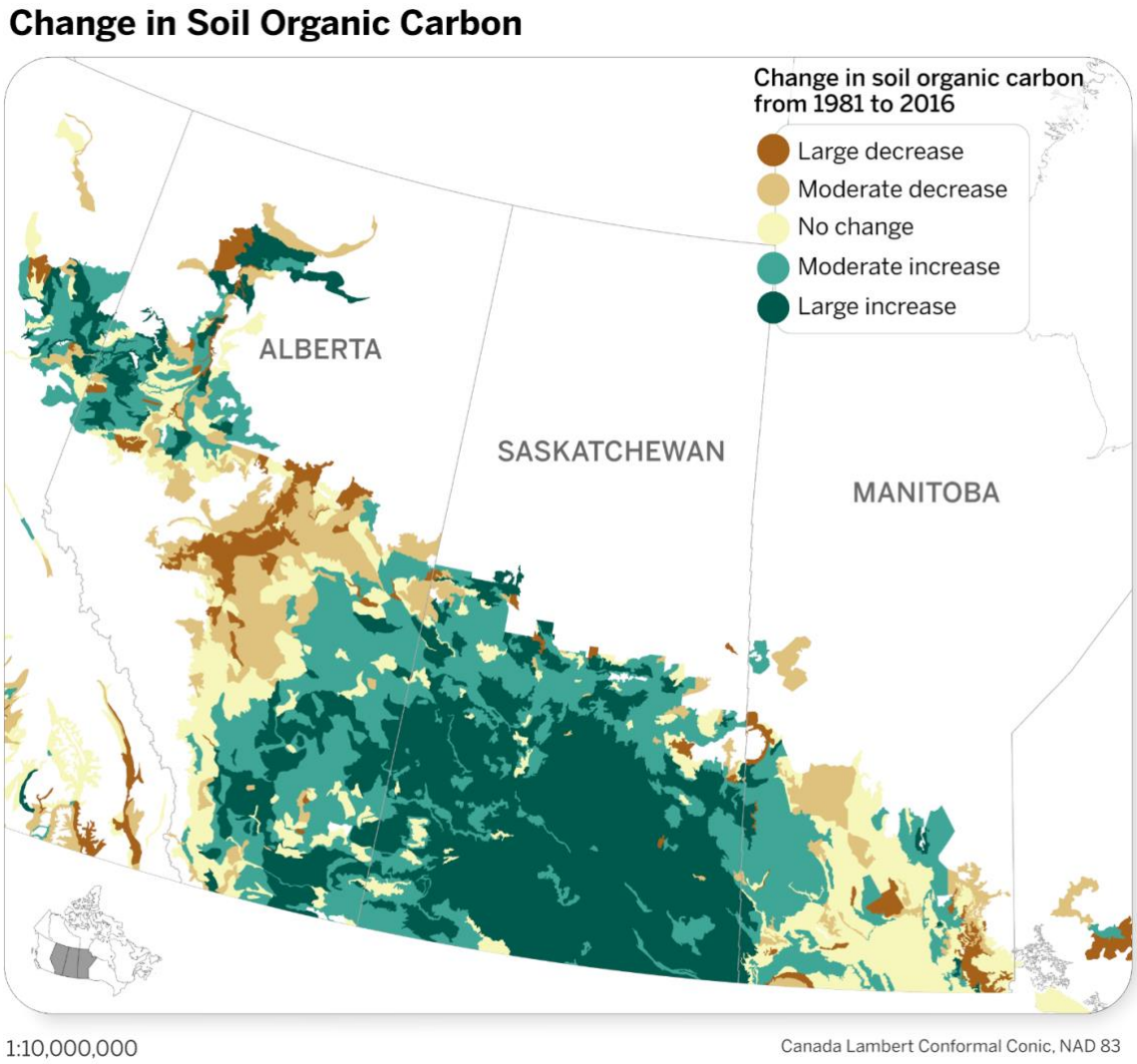
Figure 13 – Change in Soil Organic Carbon Degradation Risk: Prairies (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Regarding the change in soil organic carbon over time, Figure 14 shows a patchwork of changes throughout the Prairies from 1981 to 2016, with areas of moderate and large decrease and no change in central Alberta and southern Manitoba. Areas of moderate and large increase are shown in Alberta, southern Saskatchewan, and southwestern Manitoba.

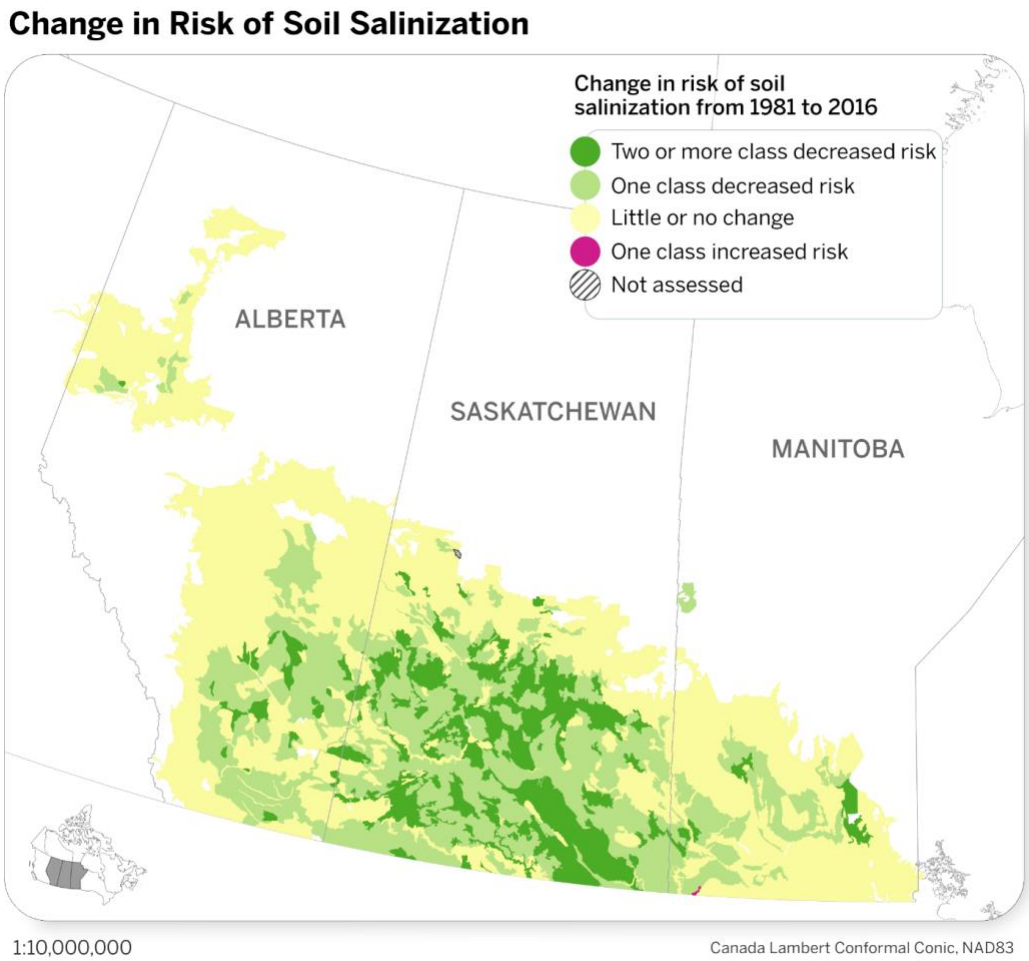
Figure 14 – Change in Soil Organic Carbon: Prairies (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Figure 15 illustrates the change over time in the estimated risk of the accumulation of soluble salts on agricultural lands in the Prairies from 1981 to 2016. At high levels, the accumulation of these salts in soil and groundwater can inhibit the growth of many crop species. Agricultural areas in southern Saskatchewan exhibit moderate to large decreases. Alberta and Manitoba exhibit decreases and little or no change relatively equally. One small area in southwest Manitoba exhibits an increased risk of salinization.

Figure 15 – Change in Risk of Soil Salinization: Prairies (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Risk of Soil Salinization*, 17 November 2020; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

On its fact-finding mission in Saskatchewan at Discovery Farm Langham, the committee saw first-hand how salinity-affected soils were vulnerable to salt-tolerant weeds such as kochia and foxtail barley. During its hearings, the committee heard that soil salinity is generally stable in Manitoba, but that it can also fluctuate.[64] It also heard that, in Alberta, soil salinity is forgotten in many areas, especially in a wet cycle, and that it becomes an issue as soon as a dry cycle comes.[65] Witnesses

[64] AGFO, *Evidence*, 20 April 2023 (Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba).
[65] AGFO, *Evidence*, 20 April 2023 (Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta).

said that putting in forages, collaborating, and looking at research, the economics and the regionality of the issues is where they can do the most work for managing salinity.

Alberta

Alberta has approximately 49 million acres of farmland, or one-third of Canada's total. This includes 1.8 million irrigated acres, more than 70% of the country's total. The province is home to about 22 million acres of forage and 27 million acres of annual crop production. According to AAFC, between 2018 and 2022 Alberta's top three crop and livestock commodities by average farm cash receipts were: cattle and calves ($5.5 billion), canola ($3.1 billion), and wheat ($2.5 billion).[66]

Tall grass grows in a field in Alberta with rolling hills in the backgroud.

Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta, informed the committee that Alberta's soils are "well-functioning," less susceptible to erosion, and more resilient to stress. Wallace explained that farmers have reduced summer fallow; adopted reduced tillage, including livestock in production systems; implemented intensive and rotational grazing practices; and diversified rotations by including legumes and perennials.[67]

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[66] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[67] AGFO, *Evidence*, 20 April 2023 (Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta).

These practices have helped to increase soil organic matter and soil carbon levels; however, Wallace cautioned that the work is far from complete as some soils are eroding and becoming more saline, acidic, or compacted. For example, soils such as the Gray Luvisols require more careful management and are at greater risk of degradation. Gray Luvisols typically occur under boreal or mixed forest vegetation and in forest-grassland transition zones in a wide range of climatic areas.[68] Weather, disease, pests, oil and gas-related activities, and evolving production practices impact the soil's ability to function. "Without thoughtful management," said Wallace, "these factors will undermine our gains."[69]

Wallace said that financial incentives such as those delivered by the Sustainable CAP must be supported, as well as applied on-farm testing of new practices; adoption and long-term maintenance of beneficial management practices; business risk management tools that provide operational risk protection when changing practices; and opportunities for ecological goods and services.[70]

> *"But soil is represented by nobody. All the commodity groups depend on soil, but none of the commodity groups are directly soil focused. It's all part of the system, and there have been a lot of initiatives by them to maintain and improve our soils. But it is not like they have a voice at the table sometimes directly from soil on some of its needs — nor funding or checkoff dollars — to support programming like this. Right now, it is falling on the shoulders of individual producers. They are collecting data and improving their systems, and we are just not aggregating it up to provincial."*
>
> *Trevor Wallace*[71]

Saskatchewan

Saskatchewan holds over 40% of Canada's total cropland and one third of Canada's native grass and forage land. According to the 2022 National Inventory Report, Saskatchewan producers sequestered almost 13 million tons of carbon in 2020, almost 80% of the province's total

[68] Government of Canada, *Gray Luvisol (GL)*.
[69] AGFO, *Evidence*, 20 April 2023 (Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta).
[70] Ibid.
[71] Ibid.

agriculture emissions. Recent research commissioned by the Global Institute for Food Security found that Saskatchewan's net carbon footprint for canola and wheat production was more than 60% lower than competitive jurisdictions and for dry field peas, it was 95% lower.

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for Saskatchewan were: canola ($5.8 billion), wheat ($4.0 billion), and cattle and calves ($1.5 billion).[72]

From left, senators David M. Arnot, Sharon Burey, Paula Simons, Rob Black and Brent Cotter tour the Glacier FarmMedia Discovery Farm in Langham, Saskatchewan.

Rick Burton, Deputy Minister of Agriculture, Government of Saskatchewan, told the committee that about 95% of the province's land seeded to annual crops is done using zero or minimum tillage, representing a major increase from 36% in 1991.[73] This is a higher percentage than any other province or territory. Burton said Saskatchewan producers have also adopted a diverse crop rotation, including oilseeds, pulses, and cereals. Growing a rotation of crops fertilized with balanced nutrients contributes to producing optimum yields, thereby helping to optimize carbon sequestration, nutrient cycling, and soil structure.

Jocelyn Velestuk, Farmer, Grain Growers of Canada, highlighted that long-term studies, such as the Prairie Soil Carbon Balance Project, have reported that there is still incremental positive carbon

[72] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[73] AGFO, *Evidence*, 30 March 2023 (Rick Burton, Deputy Minister of Agriculture, Government of Saskatchewan).

change, even 30 years after Saskatchewan farmers switched to no-till/continuous cropping practices: "The gains occur even deeper in the soil profile than originally thought. Saskatchewan farmers sequester enough carbon in the soil every year to be equivalent to removing 10 million cars from the roads."[74]

Rick Burton also said Saskatchewan is investing more than $35 million annually in agriculture research and innovation, with $6.4 million directly impacting soil health and research into soil health and an additional $22 million indirectly supporting soil health through breeding and other related activities.

> *"Our producers are contributing to soil conservation and management, and they are making substantial contributions to global food security. Yet, federally, producers are not always recognized for these contributions."*
>
> *Rick Burton*[75]

Jocelyn Velestuk mentioned that most soil survey mapping and data collection occurred in the 1980s in the Prairies and that it has been tabulated into an online mapping platform in Saskatchewan:

"Specific agricultural areas can build and improve on the soil survey digital maps with improved LiDAR data and other layers of data to get a better understanding of soil properties, such as soil organic carbon, and to help direct sample points for soil fertility measurements in the field. Ground truthing the data is also important to improve these maps."[76]

In terms of barriers, Candice Pete-Cardoso, Director, Indigenous Land Management Institute, University of Saskatchewan, informed the committee that, traditionally, First Nations vary widely in the number and capacity of staff involved in making land management decisions, with implications for caretaking of soil health:

"For many First Nations across the Prairies, there may be a single land manager who is responsible for an expansive range of duties, one of which may be negotiating and administering permits and leases with producers to rent reserve farmland. However, if the land manager leadership or

[74] AGFO, *Evidence*, 9 March 2023 (Jocelyn Velestuk, Farmer, Grain Growers of Canada).
[75] AGFO, *Evidence*, 30 March 2023 (Rick Burton, Deputy Minister of Agriculture, Government of Saskatchewan).
[76] AGFO, *Evidence*, 9 March 2023 (Jocelyn Velestuk, Farmer, Grain Growers of Canada).

members of a land advisory committee don't have a strong foundation in agriculture, including soil management, soils have the potential to be degraded."[77]

Rick Burton mentioned that the province had recently hired a senior Indigenous adviser and set up an Indigenous unit to help engage with First Nations and Métis communities in Saskatchewan: "We have a team of regional specialists, called the Building and Strengthening Indigenous Supports group, which is trying to build relationships to help Indigenous communities take advantage of the agriculture opportunities that exist for them and where they are seeing interest in expanding those."[78]

Manitoba

Agricultural production in Manitoba occurs primarily within the black soil zone, a highly productive soil that is more resilient in the face of degradation. Manitoba also has a high rate of minimum- and zero-till adoption. The western part of the province has clay loam soils, a drier climate, and is well-suited to a no-till production system. In recent years, Manitoba has experienced moisture extremes ranging from extreme drought in 2021 to excess moisture from spring storms in 2022.

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for Manitoba were: canola ($1.7 billion), wheat ($1.3 billion), and hogs ($1.2 billion).[79]

Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba, told the committee that the most critical degradation issues affecting soil health in the province right now are soil salinity and soil compaction, both of which have a direct impact on soil productivity and are a major challenge for farmers. Riekman pointed out that managing these soil health problems often requires a shift in how farmers manage the landscape. For example, farmers might seed saline areas with salt-tolerant forage or minimize traffic over the field to reduce soil compaction.[80]

Jake Ayre, Vice President, Keystone Agricultural Producers of Manitoba, said: "Manitoba farmers recognize the benefits of enhancing and preserving soil health. This is done mainly through crop rotation, grazing management, zero-till practices, soil sampling, nutrient management, the 4Rs, prevention of soil compaction, and planting cover crops."[81]

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[77] AGFO, *Evidence*, 9 February 2023 (Candice Pete-Cardoso, Director, Indigenous Land Management Institute, University of Saskatchewan, As an individual).
[78] AGFO, *Evidence*, 30 March 2023 (Rick Burton, Deputy Minister of Agriculture, Government of Saskatchewan).
[79] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[80] AGFO, *Evidence*, 20 April 2023 (Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba).
[81] AGFO, *Evidence*, 4 May 2023 (Jake Ayre, Vice President, Keystone Agricultural Producers of Manitoba).

For some of these management strategies Riekman said there is a lack of information on the economic impact on the farm: "As an extension specialist who encourages farmers to adopt soil health practices, this is often one of my biggest struggles. Do we have enough research that not only demonstrates the environmental benefit of these practices, but also the agronomic and economic benefit of these practices?"[82]

> *"Farmers need to realize a return on investment when they are adopting new practices. If practices are known to provide a return, it is more likely that adoption will increase based on peer-to-peer knowledge sharing. When there is not a return to the farmer, but the public sees a great benefit to the practice, this is when funding programs are needed to drive adoption."*
>
> *Marla Riekman*[83]

Riekman noted that adoption of soil health practices may also be slower on rented acres in Manitoba, a trend that is also increasing throughout the country. The National Farmers Union confirmed that 40% of farmland in Canada is currently rented.[84]

In northern Manitoba, soil health practices are often practiced within the forestry industry, looking at how to maintain or manage peatlands and dealing with carbon sequestration. For example, there is a small Manitoba Agriculture project currently looking at carbon stocks, throughout the agricultural sector, as well as in peatlands and forested areas. The committee heard that Manitoba is the third-largest producer of peat in Canada, following Quebec and New Brunswick, respectively.[85]

Riekman highlighted the importance of documenting change over time and not just a number at one period. Riekman said Manitoba is one of the few provinces and territories that continues to provide extension services to its farming community: "Extension offers a critical link between researchers and farmers, acting as an information conduit between these groups. We have an opportunity to connect with local producer groups to identify key research gaps, including the long-

[82] AGFO, *Evidence*, 20 April 2023 (Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba).
[83] Ibid.
[84] AGFO, *Evidence*, 29 February 2024 (Stuart Oke, Co-Owner of Rooted Oak Farm, National Farmers Union).
[85] AGFO, *Evidence*, 14 December 2023 (Asha Hingorani, President, Canadian Sphagnum Peat Moss Association).

term economic impact of soil health practices, as well as indicators that farmers can use to identify if they're making a difference."[86]

"There are a lot of behavioural changes that come with soil health BMPs [beneficial management practices], especially when we're dealing with managing fields on a soil basis as opposed to a section or quarter section basis. That is something that I think we haven't looked at enough: the behavioural changes and the social idea of how we encourage more of the adoption of those practices. A lot of it will come down to the economic decision-making and the drivers for those farmers," said Riekman.[87]

Witnesses told the committee that neither Alberta nor Manitoba has had the same working relationship with the federal government since the loss of the Prairie Farm Rehabilitation Administration (PFRA) Shelterbelt Centre, which was a federal entity on the ground in the Prairies. The PFRA opened in Indian Head, Saskatchewan in 1935 and operated for 77 years until it closed in 2012. The PFRA was funded by AAFC. Witnesses said its closure shifted how the Prairie provinces interact with the federal government. As a result, the Prairie provinces are working more closely with the producers on the extension side.[88]

Marla Riekman reported that Manitoba's soil surveys date back to the 1950s and that they only have a reconnaissance-scale soil survey, which is a very broad kind of scale that is not appropriate to be used on a field scale decision-making level: "Unfortunately, at this current time, we don't have detailed scale or that farm field-level scale soil survey across all of Manitoba Agriculture. We're still trying to get that done."[89]

Trevor Wallace said there is a need for financial support to bring the regions together, while Marla Riekman added that it was time to recognize whom soil health benefits: "I think the big thing around soil health, we have that private benefit to the farmer, obviously, by protecting the soil and being able to create that, but there are also benefits from farmers managing soil health that are seen to the public as well."[90]

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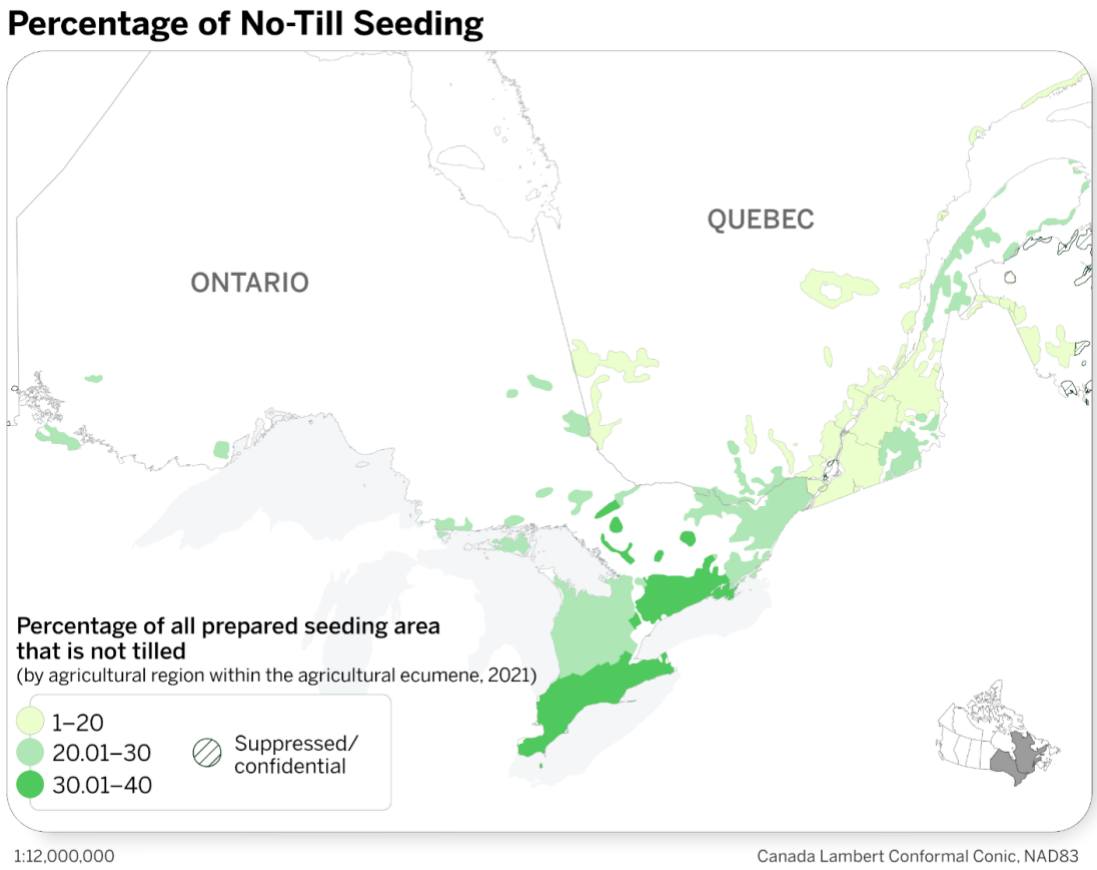
[86] AGFO, *Evidence*, 20 April 2023 (Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba).
[87] Ibid.
[88] AGFO, *Evidence*, 20 April 2023 (Patti Rothenburger, Assistant Deputy Minister, Manitoba Agriculture, Government of Manitoba).
[89] AGFO, *Evidence*, 20 April 2023 (Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba).
[90] Ibid.

Central Canada

In Central Canada no-till has been adopted at around 20% to 40% of hectares prepared for seeding in Ontario and up to 30% in Quebec, as illustrated in Figure 16. Witnesses explained that wetter climatic conditions in the East increase soil compaction and, thus, the need for tilling. Also, witnesses said that differences in the size and type of agricultural production systems between Central and Western Canada may also explain these trends.

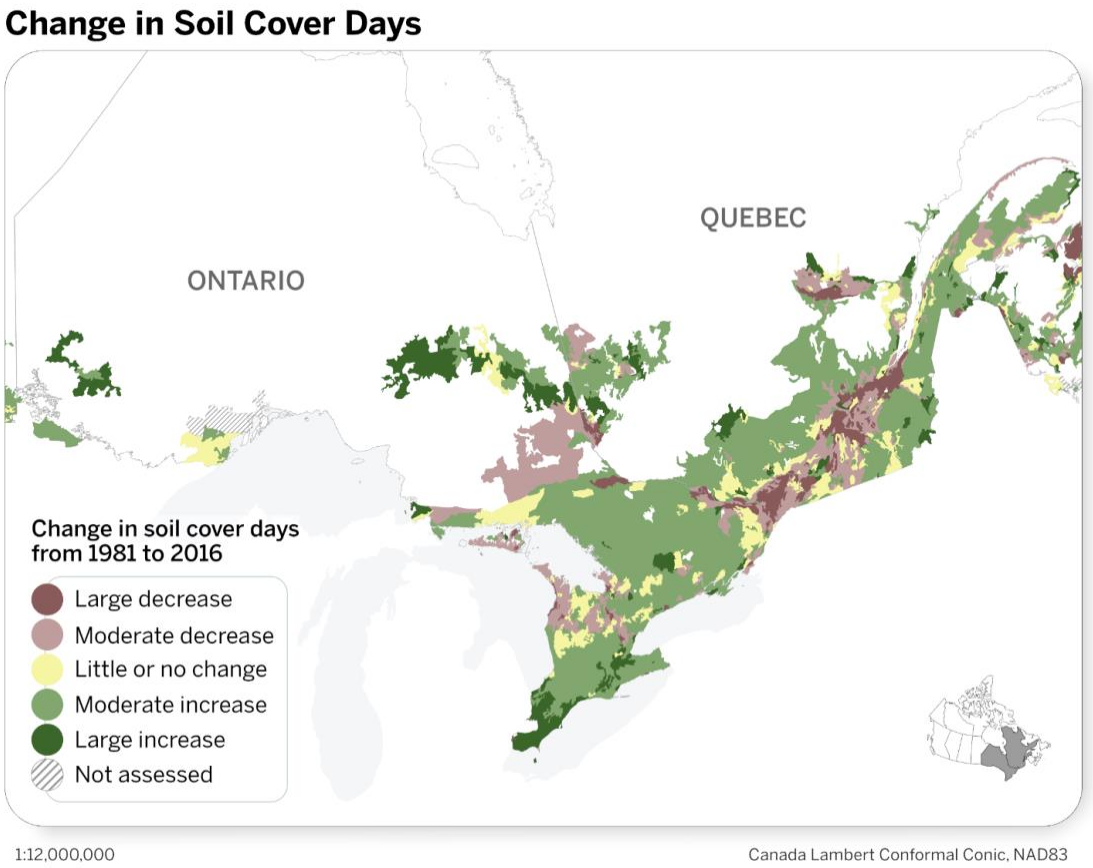
Figure 16 – Percentage of Hectares Prepared for No-Till Seeding: Central Canada (2021)



Sources: Map prepared in 2024 using data obtained from Statistics Canada, "Table 32-10-0367-01: Tillage and seeding practices, Census of Agriculture, 2021," Database, accessed 28 November 2023; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Statistics Canada Open Licence*.

Regarding change in soil cover days, most areas in Ontario and Quebec exhibit moderate increases from 1981 to 2016, as shown in Figure 17. There are moderate decreases in the Sudbury area and larger decreases the Montréal area and along the banks of the lower St. Lawrence River.

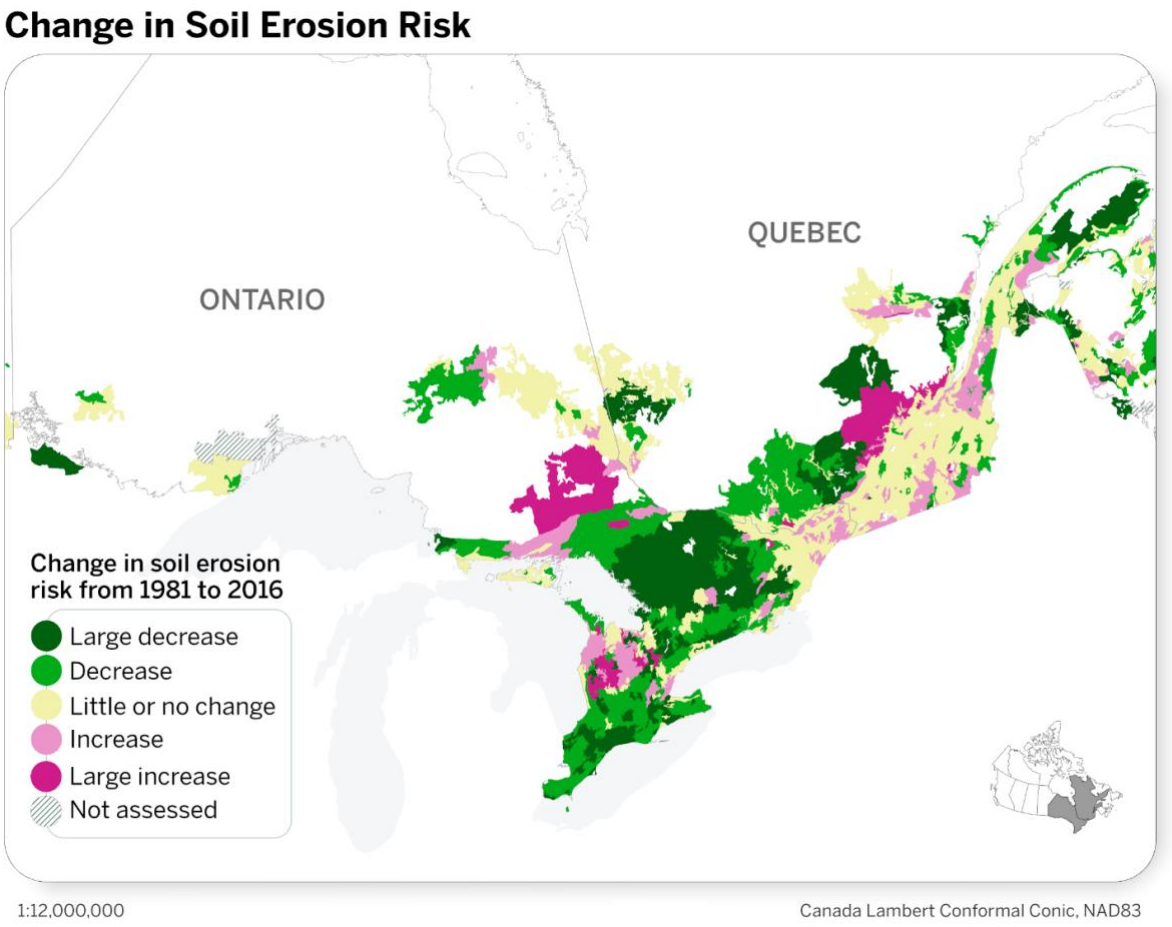
Figure 17 – Change in Soil Cover Days: Central Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Cover Days*, 16 December 2020; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Large increases in soil erosion risk for the period 1981 to 2016 appear in the region of Sudbury, Ontario and in Quebec between Montréal and Trois-Rivières, while large decreases appear around Algonquin Provincial Park and Kawartha Lakes in Ontario, and in the Laurentian Mountains in Quebec, as shown in Figure 18.

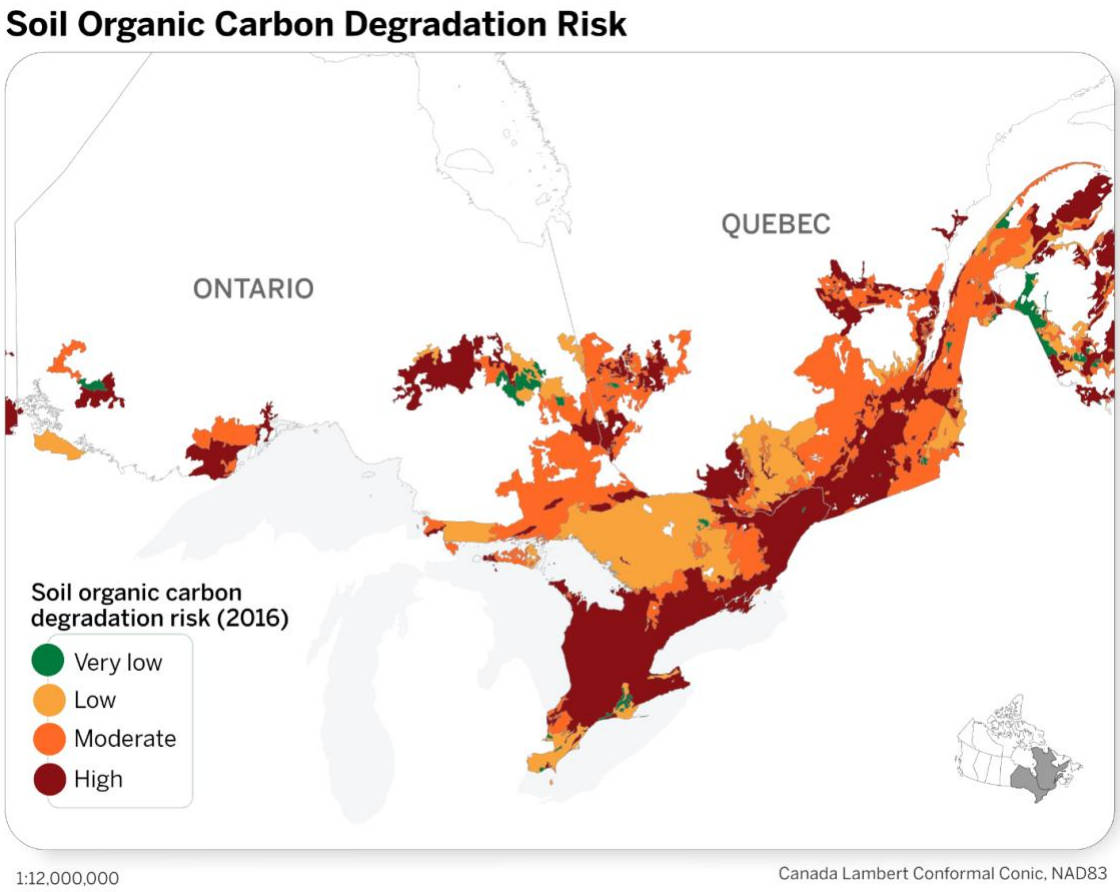
Figure 18 – Change in Soil Erosion Risk: Central Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Risk of Soil Erosion*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

In 2016, large areas of Ontario and Quebec exhibited moderate to high levels of risk of soil carbon degradation, as shown in Figure 19. Land management and land-use changes, most notably the conversion from perennial crops – which provide year-round coverage of soils – to annual crops, may explain this trend in Central Canada.

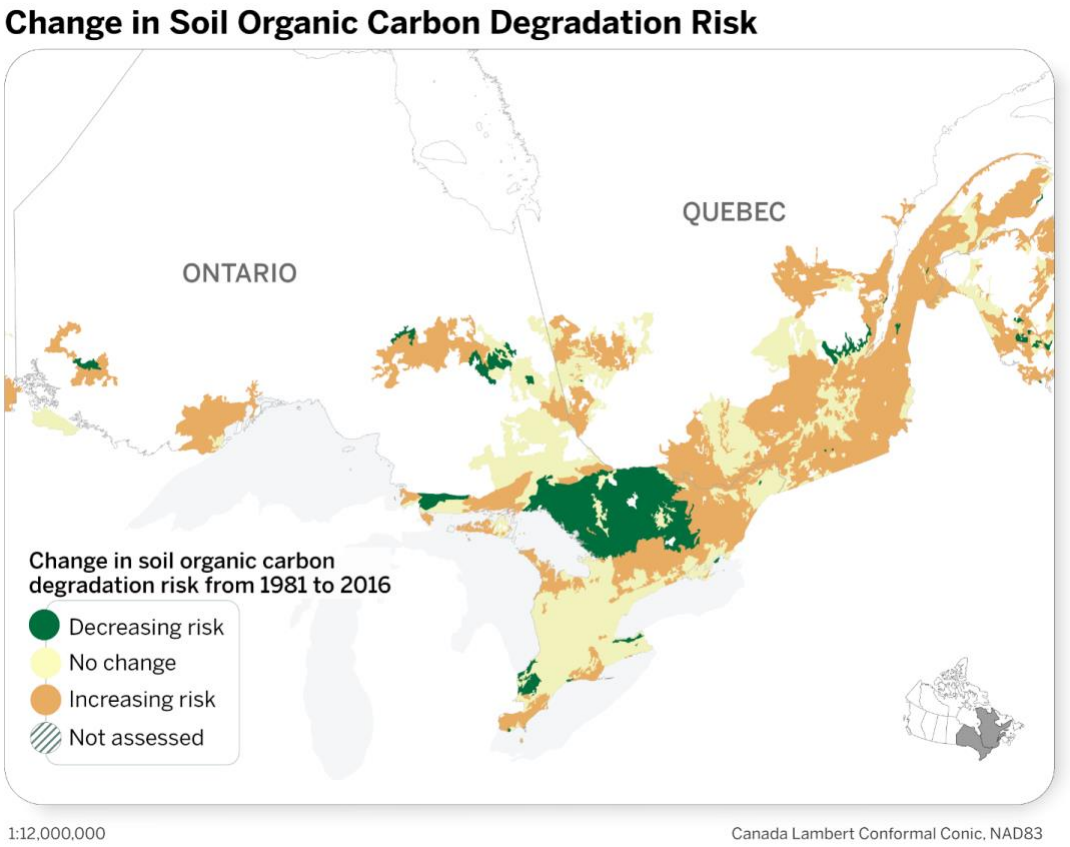
Figure 19 – Soil Organic Carbon Degradation Risk: Central Canada (2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Regarding change in soil carbon degradation risk for the period 1981 to 2016, Figure 20 shows that most regions in Ontario and Quebec are classified as having increasing risk, with pockets in northern and central Ontario showing decreasing risk. Many areas in western Ontario showed no change.

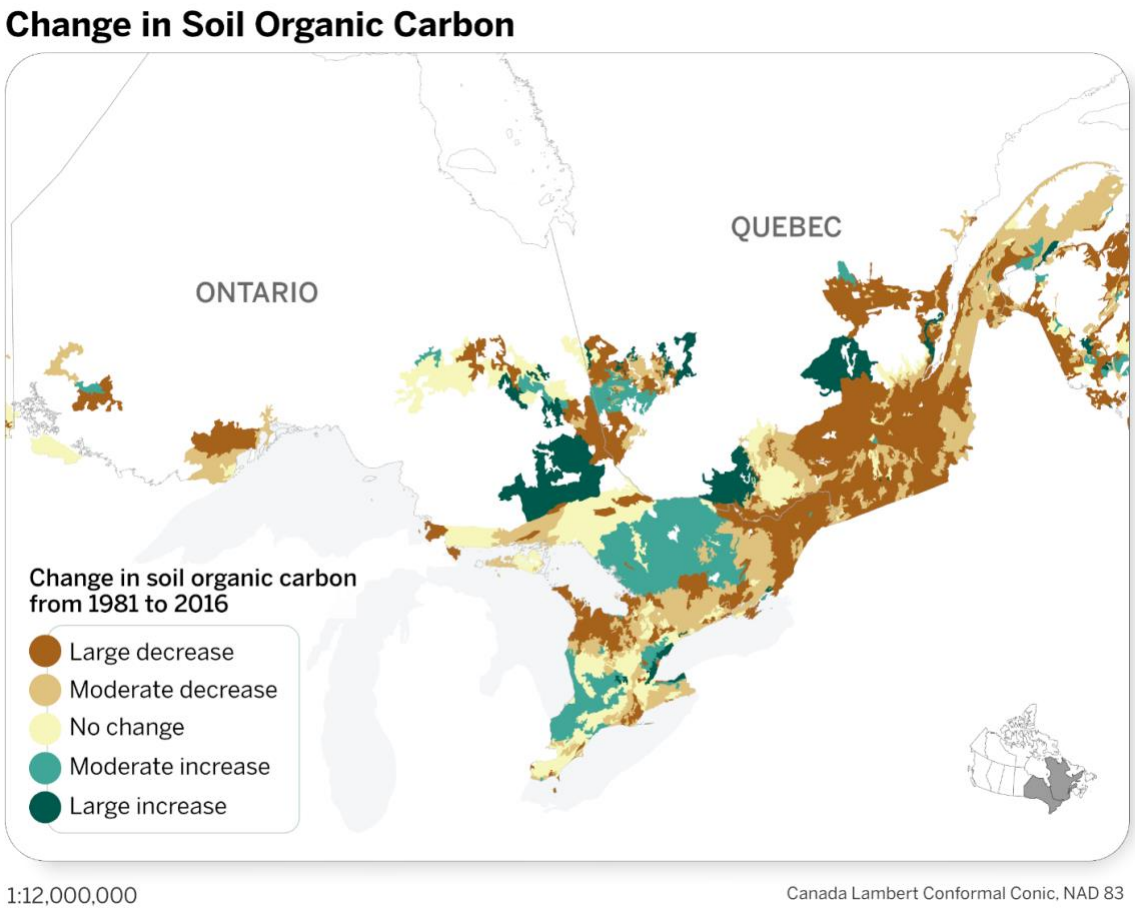
Figure 20 – Change in Soil Organic Carbon Degradation Risk: Central Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Figure 21 illustrates the change in carbon sink over time for Central Canada from 1981 to 2016, with a moderate decrease in western and central Ontario, and large decreases in southern Quebec. A moderate increase is observed in Ontario, with large increases in most of Quebec.

Figure 21 – Change in Soil Organic Carbon: Central Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Ontario

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for Ontario were: dairy ($2.3 billion), vegetables ($2.2 billion), and soybeans ($2.0 billion).[91]

[91] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.

A red barn with blue silos on a farm in Guelph, Ontario.

Christine Brown, Field Crops Sustainability Specialist, Agriculture Development Branch, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Government of Ontario, told the committee that Ontario soils, both owned but especially those that are rented, are increasingly vulnerable to erosion, compaction and decreasing soil organic matter levels. Intense rainstorms and snowmelt have increased soil erosion in some areas, but soil erosion is site-specific in certain regions.[92]

Daniel Saurette, Land Resource Specialist — Soil, Environmental Management Branch, OMAFRA, Government of Ontario, explained that while Ontario has an inherently higher risk of soil erosion, it has not increased over time. Saurette said that the province is doing a good job of managing that erosion despite many farmers having converted from perennial systems to annual crops, adding that annual cropping systems are more susceptible to erosion because they have more exposed soil. Saurette said that beneficial management practices are key to mitigating soil erosion.[93]

Brodie Berrigan, Director of Government Relations, Canadian Federation of Agriculture, noted that where there has been adoption of many of beneficial management practices in some parts of the

[92] AGFO, *Evidence*, 30 March 2023 (Christine Brown, Field Crops Sustainability Specialist, Agriculture Development Branch, Ontario Ministry of Agriculture, Food and Rural Affairs, Government of Ontario).
[93] AGFO, *Evidence*, 30 March 2023 (Daniel Saurette, Land Resource Specialist — Soil, Environmental Management Branch, Ontario Ministry of Agriculture, Food and Rural Affairs, Government of Ontario).

country, there are other competing trends in Ontario.[94] For example, dairy farmers have also become much more efficient at producing more milk with fewer cows, so they need less acreage to support their herds. Farmers have also seen increasing — and more stable — prices on a lot of cash crops. Berrigan explained it is more profitable to farm corn and soybeans in eastern Ontario.[95]

The committee learned about OMAFRA's topsoil sampling program, which started in 2019 and has tested 500 farms across the province to date. OMAFRA is building a baseline to try to understand what soil health looks like across Ontario's agricultural soils. OMAFRA also offers a field-scale program, ONFARM (On-Farm Applied Research and Monitoring) that looks at paired sites where beneficial management practices are applied on one side of the field and not on the other to then compare soil health metrics.[96]

Brandon Heung, Associate Professor, Faculty of Agriculture, Dalhousie University, said that OMAFRA "has done an exceptional job in terms of leading investments toward advancing digital soil mapping research and doing soil surveying."[97]

When asked about funding soil management programs through an equity lens, the committee learned that OMAFRA has hired more staff members from Indigenous backgrounds in their extension group, which Christine Brown said is helping with inclusivity and working with these communities.

The Ontario Federation of Agriculture has suggested that the province is losing 319 acres of arable farmland per day.[98] To halt the loss of arable land, Dean Orr, Farmer, from King City, Ontario, suggested that federal, provincial, and municipal governments implement "gentle-density growth policies" and that "agriculture should be planned into and not out of communities."[99] Orr, who farms close to Toronto, has a particular interest in urban growth and planning and what it means for the future of agriculture in Canada.

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[94] AGFO, *Evidence*, 16 February 2023 (Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture).
[95] Ibid.
[96] AGFO, *Evidence*, 30 March 2023 (Daniel Saurette, Land Resource Specialist — Soil, Environmental Management Branch, Ontario Ministry of Agriculture, Food and Rural Affairs, Government of Ontario).
[97] AGFO, *Evidence*, 20 October 2022 (Brandon Heung, Associate Professor, Faculty of Agriculture, Dalhousie University, As an Individual).
[98] Tyler Brooks, "Ontario Farmland Under Intense Pressure," *News*, Ontario Federation of Agriculture, 10 June 2022.
[99] AGFO, *Evidence*, 9 November 2023 (Dean Orr, Farmer, As an individual).

> *"It is the great irony of the lifespan of our farm that we have been practising good crop rotation, no-till and cover cropping for decades, vastly improving the soil health in our fields and limiting the environmental impact of our operation, only for that work to be destroyed within the next 50 years, unless something changes in how our society thinks about the worth of land — and how we go about planning for its use."*
>
> *Dean Orr*[100]

The committee also heard from Cheyenne Sundance who has been farming for four years and who represents Sundance Commons – an Ontario non-profit organization that provides land leases, equipment, and supportive mentorship to new farmers across southwestern Ontario's Golden Horseshoe. Sundance Commons believes that a new farming model is needed and would like to see support for the legal designation of community land trusts regarding agricultural land in Canada. The organization is inspired by models that offer farmers equity for land-based improvements to soil health such as shares or bonds that are tied to organic matter increases in the soil, or an improvement for the soil microbiome for developing hedgerows.[101]

When asked about how easy it was to access funds from the federal AgriDiversity program, Sundance told the committee that she did not know that the program existed.[102] AgriDiversity is a $5-million program under the Sustainable CAP. One of the objectives of the program is to support projects aimed at helping Indigenous Peoples and other underrepresented and marginalized groups in Canadian agriculture — including women, youth, persons with disabilities, racialized persons, visible minorities, 2SLGBTQI+ communities, and official language minority communities — to fully participate in the sector by helping these groups address the key issues and barriers they often face for sector participation.[103]

Quebec

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for Quebec were: dairy ($2.6 billion), hogs ($1.6 billion), and poultry ($898 million).[104]

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[100] Ibid.
[101] AGFO, *Evidence*, 9 November 2023 (Cheyenne Sundance, Farmer, Sundance Commons).
[102] Ibid.
[103] Government of Canada, "*AgriDiversity Program: Step 1. What this program offers*."
[104] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.

A harvest harrow tractor moving through a cranberry bog in Plessisville, Quebec.

Several witnesses told the committee the main threats to soil degradation in Quebec are soil erosion, low soil organic carbon, decline in agricultural land, and water resource management.

The Union des producteurs agricoles (UPA) and the Producteurs du grains de Québec said agricultural soils in Quebec are under stress from factors that can jeopardize their medium- or long-term fertility.[105] Martin Caron, President and CEO, UPA, cited problems with soil erosion and loss of organic matter, but also said that a growing number of producers are implementing solutions.[106]

Caron stated the federal government has a role to play in fostering the adoption of best practices in soil conservation. Caron explained that while intense and specialty production systems have many benefits, especially in terms of volumes produced, these same systems also present challenges when it comes to sustainability. For example, Caron said a long rotation with several types of crops has many advantages over a rotation with only two crops, such as corn and soybeans in Quebec; however, the short-term profitability of these two crops is more attractive to farmers who specialize in growing them. Other crops that can be introduced are usually less lucrative.[107]

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[105] AGFO, *Evidence*, 16 February 2023 (Martin Caron, President and CEO, Union des producteurs agricoles).
[106] AGFO, *Evidence*, 8 June 2023 (Benoit Legault, Director General, Producteurs du grains de Québec).
[107] AGFO, *Evidence*, 16 February 2023 (Martin Caron, President and CEO, Union des producteurs agricoles).

Caron added that practices which provide long-term benefits for soil health and the environment—such as green manures and cover crops—pose short-term profitability issues for producers. Green manures are field crops that are planted within a rotation to add nutrients and organic matter to the soil and can include legumes and non-legumes. The barrier to change for producers in Quebec is that during the transition period revenues are lower, expenses are higher, and the benefits of healthier soils have not yet been reaped. Another constraint for producers is learning how to manage greater complexity on farm such as acquiring new knowledge, trial, and error experimentation, and adjusting practices to specific situations.[108]

Caron told the committee that the UPA is carrying out various soil-health initiatives, including collaborating with AAFC, to promote the adoption of better farming practices in Quebec. [109]

Caron also mentioned that the Research and Development Institute for the Agri-Environment conducted a study at the request of the Government of Quebec's Ministry of Agriculture, Fisheries and Food (MAPAQ). The final report will provide a diagnosis of the health of agricultural soils in Quebec. The UPA submitted requests to the MAPAQ for an assessment/overview of the condition of soil health throughout the province, specifically a carbon neutral assessment. With the clay soils in Quebec, soil compaction must be considered, and more research is needed on this aspect.

Catherine Lefebvre, President, Association des producteurs maraîchers du Québec, said that climate change is causing increased costs and decreased productivity for vegetable producers.[110]

Catherine Lessard, Deputy General Manager, Association des producteurs maraîchers du Québec, told the committee that over 50 different vegetable crops are grown in Quebec, most of which production occurs in the Montérégie and Lanaudière regions, where the climate and soils are favourable.[111] Both regions, however, are located near Montréal and subject to urban pressure. Recent projections show a 22% population increase in the municipality of Jardins-de-Napierville, and 18% in the Montcalm regional county municipality. Lessard said that "measures to preserve agricultural land are essential to ensure that exceptional soil is not used for other purposes."[112]

Annual sales of vegetables in Quebec reached $500 million in 2020, which is similar in value to Quebec maple syrup, yet Lessard said that research in the vegetable sector is underfunded in comparison to other sectors. For example, Lessard said that while soil health is one of the subjects of the Living Labs Quebec project, jointly funded by AAFC and the UPA, it does not include the vegetable sector: "Due to the diversity of crops and production models, soil health improvement

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[108] Ibid.
[109] Ibid.
[110] AGFO, *Evidence*, 8 June 2023 (Catherine Lefebvre, President, Association des producteurs maraîchers du Québec).
[111] AGFO, *Evidence*, 8 June 2023 (Catherine Lessard, Deputy General Manager, Association des producteurs maraîchers du Québec).
[112] Ibid.

techniques for vegetable production are less documented, and our producers do not know the techniques that are documented very well."[113]

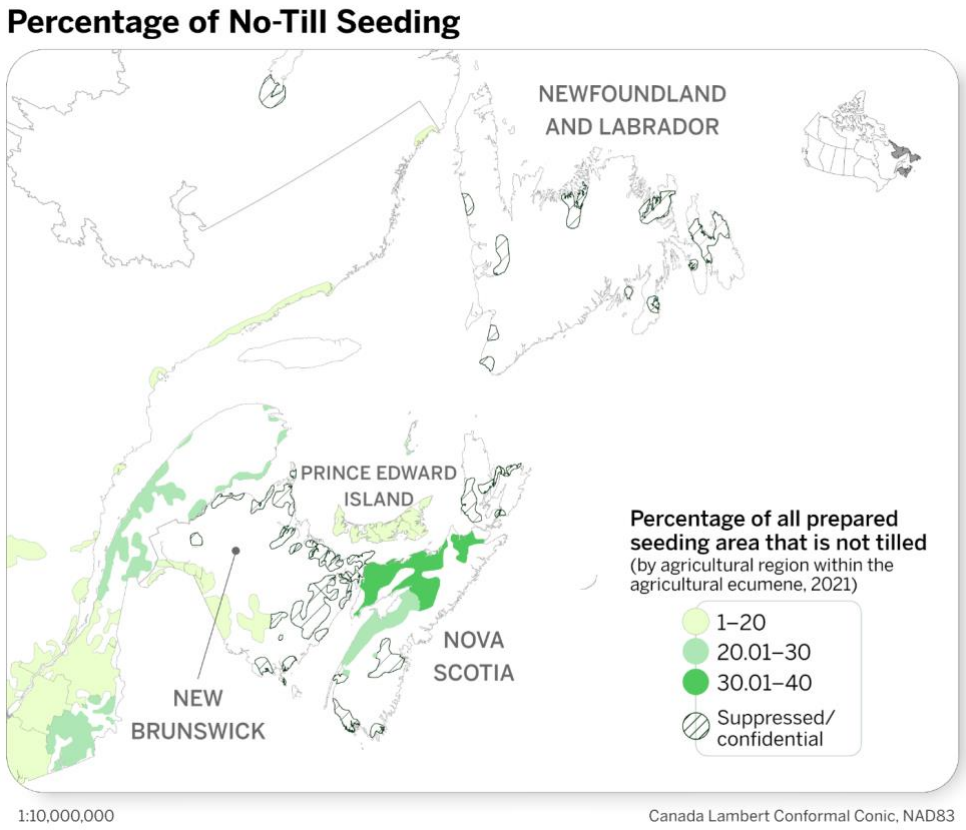
Lessard said that public funding is essential to meet this challenge, and to improve soil health in general. In this respect, restoring financial support for the AgriScience clusters research projects to 75% would be a step in the right direction. For the time being, Lessard said only soil health projects focusing on carbon sequestration are eligible for subsidies of more than 50%.[114]

Atlantic Canada

In Atlantic Canada, no-till is practiced on up to 20% of hectares prepared for seeding in parts of New Brunswick, up to 20% in all of Prince Edward Island, and between 30% to 40% in parts of Nova Scotia, as shown in Figure 22. Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University, said: "In recent work across very diverse farms, the benefits of amendments and reduced tillage to increase soil health in Atlantic Canada have been shown."[115]

[113] Ibid.
[114] Ibid.
[115] AGFO, *Evidence*, 20 October 2022 (Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University, As an individual).

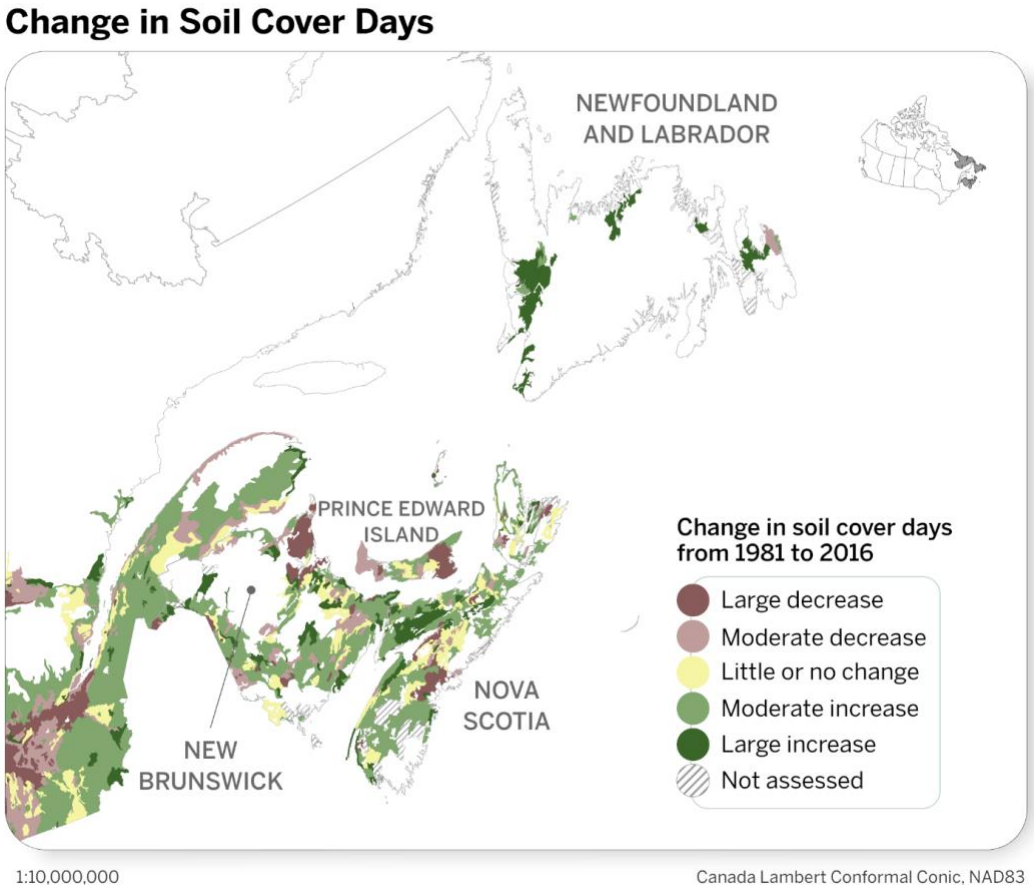
Figure 22 -Percentage of Hectares Prepared for No-Till Seeding: Atlantic Canada (2021)



Sources: Map prepared in 2024 using data obtained from Statistics Canada, "Table 32-10-0367-01: Tillage and seeding practices, Census of Agriculture, 2021," Database, accessed 28 November 2023; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Statistics Canada Open Licence*.

Figure 23 presents the change in soil cover days in Atlantic Canada from 1981 to 2016. Most areas in Atlantic Canada exhibit moderate increases, with large increases in Newfoundland and Labrador. There are decreases in eastern Prince Edward Island, northwest New Brunswick and south of Halifax, Nova Scotia.

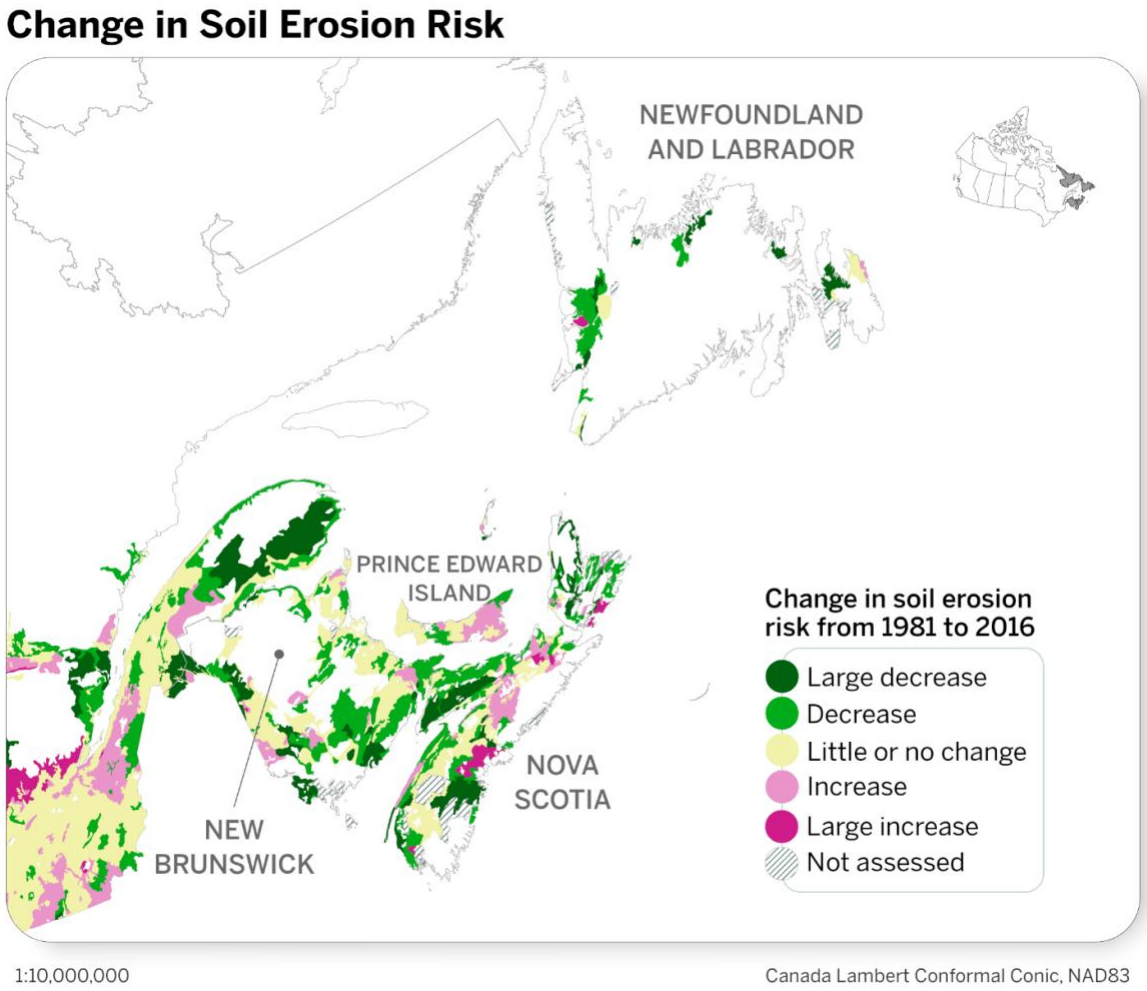
Figure 23 – Change in Soil Cover Days: Atlantic Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Cover Days*, 16 December 2020; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

As for soil erosion risk over time for the period 1981 to 2016, Figure 24 shows that in Atlantic Canada most coastal agricultural lands exhibit moderate to large decreases, while the area west of Halifax, Nova Scotia indicates a large increase.

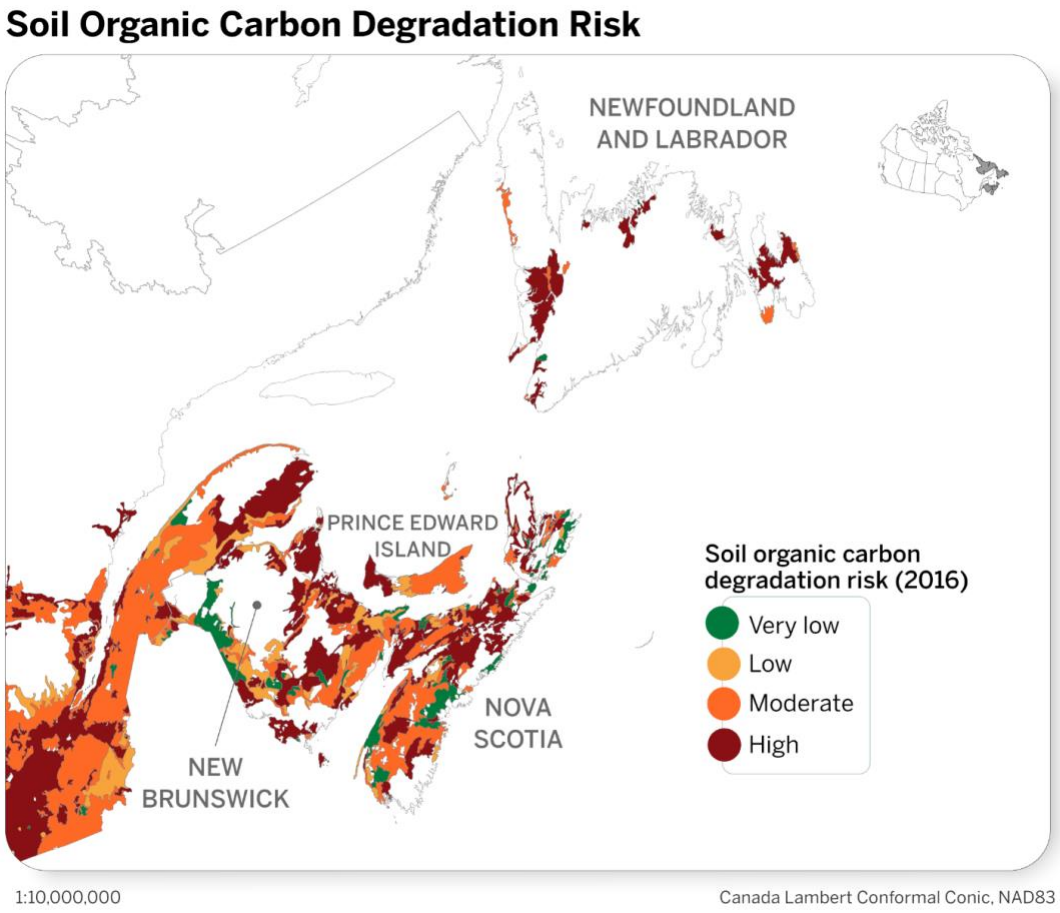
Figure 24 – Change in Soil Erosion Risk: Atlantic Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Risk of Soil Erosion*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

With respect to soil organic carbon degradation risk, Figure 25 shows that most of Atlantic Canada exhibits a patchwork of risk. Western Prince Edward Island is at high risk while eastern Prince Edward Island is at moderate risk.

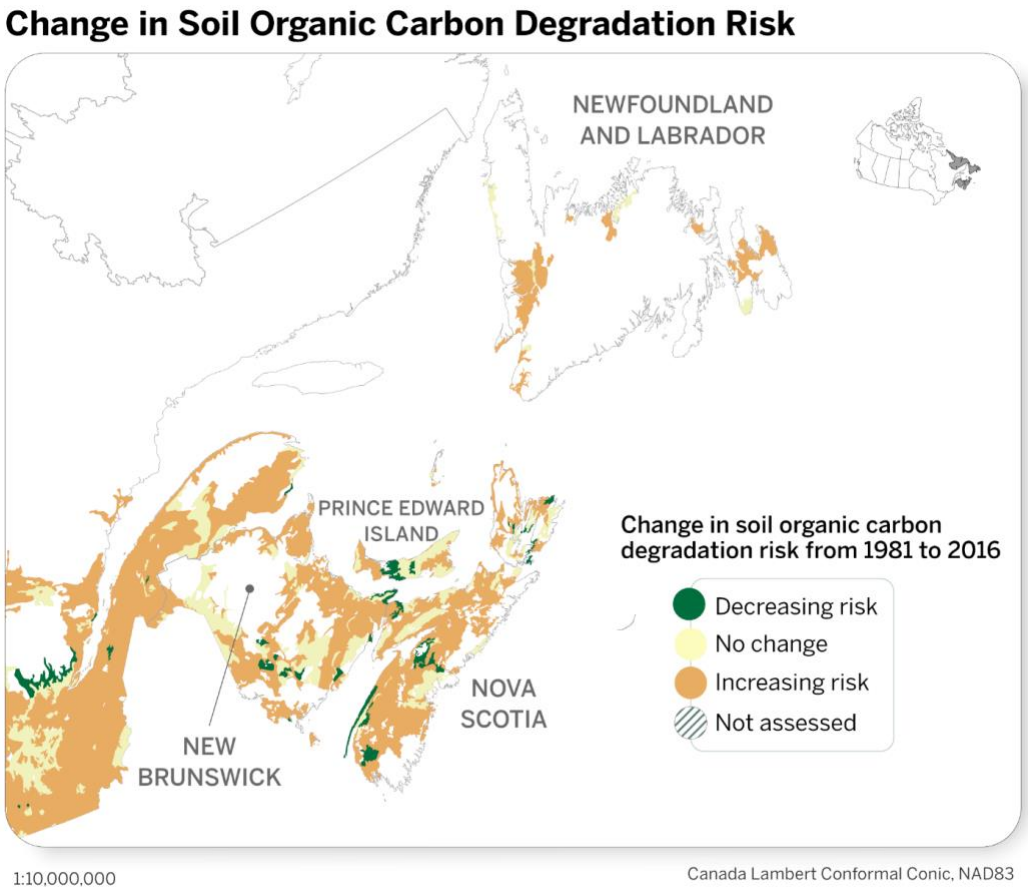
Figure 25 – Soil Organic Carbon Degradation Risk: Atlantic Canada (2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

From 1981 to 2016, most of the agricultural lands in Atlantic Canada were classified as having an increasing risk of soil carbon degradation, as shown in Figure 26.

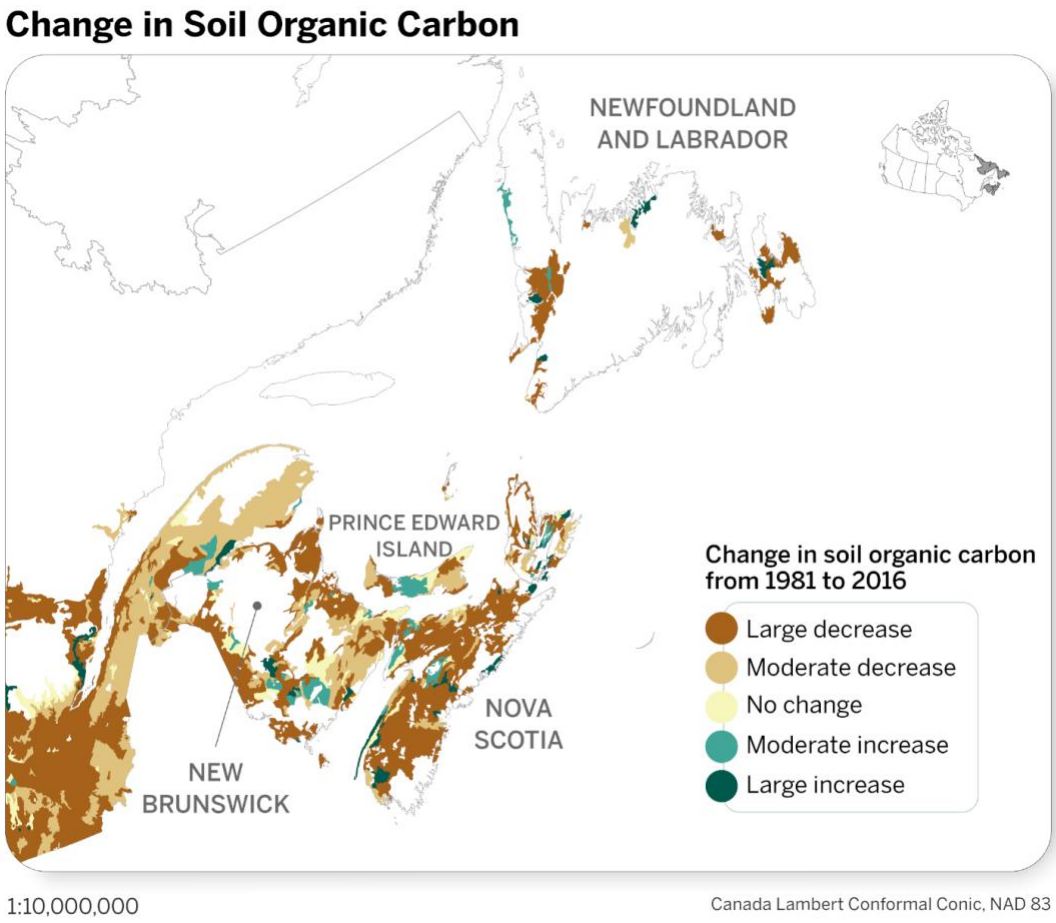
Figure 26 – Change in Soil Organic Carbon Degradation Risk: Atlantic Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

Figure 27 shows a patchwork of changes from 1981 to 2016 in the amount of soil organic carbon that is sequestered across the agricultural lands of Atlantic Canada, showing mostly large decreases across all provinces, with very small areas showing moderate or large increases.

Figure 27- Change in Soil Organic Carbon: Atlantic Canada (1981 to 2016)



Sources: Map prepared in 2024 using data obtained from Agriculture and Agri-Food Canada, *Agri-Environmental Indicator – Soil Organic Matter*, 18 January 2021; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Open Government Licence – Canada* and *Statistics Canada Open Licence*.

New Brunswick

In a brief submitted to the committee, the Government of New Brunswick, Department of Agriculture, Aquaculture and Fisheries, described the province's agricultural landscape as highly diversified. For instance, wild blueberry production occurs in the northeastern and southeastern parts of the province, cranberry production in the east, and potato production in the northwest in the Upper Saint John River Valley. Horticulture crops, including apples, small fruit, and vegetables, are mainly grown in the lower Saint John River Valley and in the southeastern part of the province.

The dairy and livestock industries are scattered around the province, primarily located in the south-central region around the town of Sussex.[116]

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for New Brunswick were: cannabis ($239 million), potatoes ($178 million), and dairy ($124 million).[117]

Only 5% of New Brunswick's land base is used for agriculture. The total farm area in production from 2016 to 2021 fell by 18% to 685,378 acres. In comparison, the total average farm area in production throughout Canada decreased by 3% during the same period. The Government of New Brunswick stated that several factors led to this decrease, including poor suitability for growing, domestic and international market fluctuations, urban sprawl, competing land use, lack of farm succession planning, and increased farm-input costs.[118]

Like much of Atlantic Canada, New Brunswick has naturally acidic soils. Many soil types and textures are found across the province. Most soils are noncalcareous, meaning they are lime deficient. The Department of Agriculture, Aquaculture and Fisheries reported that the continuous cultivation of annual crops in the province has increased soil compaction and soil erosion from wind and water, and lowered soil organic matter content and nutrient and water-holding capacity in some fields. The need for soil acidity neutralizing amendments in Atlantic Canada region has been well documented.[119]

Opportunities exist for crop and livestock production to improve soil health and increase carbon sequestration. For example, the Department of Agriculture, Aquaculture and Fisheries recently conducted an evaluation of the province's soil health to identify opportunities and sources of residual amendments. The status of soil health was evaluated in 15 counties with soil data from the Prince Edward Island (PEI) and Ontario laboratories. The evaluation consisted of reviewing close to 125,000 soil test results collected from 2010 and 2021. The results showed that 100% of the soil had below-recommended pH levels for optimal field crop and vegetable production, and only 40% of the soil samples were at optimum pH levels for potato production. Soils with low pH levels create challenges in terms of overall yield reduction and increased fertilizer use.[120]

Soils were also low in calcium, a common deficiency in noncalcareous soils, especially in soils with low pH levels. Soil phosphorus levels were at optimum levels for field crops, wild blueberries, and vegetables, but would not meet the optimum levels required for potato production. Aluminum, which is naturally present and found at high levels in New Brunswick's soils, affects the availability

[116] AGFO, *Brief*, 31 March 2023 (Government of New Brunswick, Department of Agriculture, Aquaculture and Fisheries).
[117] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[118] AGFO, *Brief*, 31 March 2023 (Government of New Brunswick, Department of Agriculture, Aquaculture and Fisheries).
[119] Ibid.
[120] Ibid.

of phosphorus for the crop. Potassium was also below optimum levels for field crops, vegetables, and potatoes, which can lead to a higher incidence of disease and insect damage. Optimal potassium rates are important for many crops grown in the province, but excessive potassium levels decrease calcium and magnesium uptake. Sulfur levels were optimum for wild blueberries, potatoes, field crops and vegetables. In addition, soil structure degradation from continuous production is a challenge throughout the province.[121]

For several years, New Brunswick's Department of Agriculture, Aquaculture and Fisheries has collaborated with other provincial departments, AAFC, agricultural associations, various stakeholders, and producers to increase awareness and support producers with the adoption of business management programs (BMPs). The Environmental Farm Plan has been delivered by the province since 1996 and has been a key program to increasing on-farm environmental sustainability, including a focus on soil management. Financial support for BMPs associated with the environment, climate change and soil health from the federal, provincial, and territorial cost-shared framework are a focus area for New Brunswick under the new Sustainable CAP.[122]

[121] Ibid.
[122] Ibid.

Nova Scotia

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for Nova Scotia were: dairy ($156 million), fruit ($73 million), and eggs ($46 million).[123]

Sean Thomas, Research Professor, University of Toronto, told the committee: "I have an impression that Nova Scotia is doing pretty well. It has a pretty long legacy of degradation, but they have put in some real investments given the smaller forest area."[124]

The committee learned that Dalhousie University's Centre for Sustainable Soil Management brings together 35 soil scientists and academics in related disciplines across six provinces. The centre's mission is to advance scholarship and research in soil science; to provide a focal point for soil science, education, and training in Atlantic Canada; and to serve as a national data hub for data-intensive mapping, understanding and use of soil landscape information and the impact of management on those landscapes.

Prince Edward Island

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for Prince Edward Island were: potatoes ($253 million), dairy ($94 million), and cattle and calves ($34 million).[125]

Carla Millar, Manager, Sustainable Agriculture, Department of Agriculture, Government of Prince Edward Island, informed the committee that while the province's rich red soil is known to grow some of the highest-quality food, its sandy texture coupled with the rolling topography of its fields can lead to soil health challenges. Under annual crop production systems, soil is easily lost to wind and water erosion, and organic matter is hard to maintain.[126]

The committee learned that in 1998, PEI started a long-term province-wide soil quality monitoring project to routinely assess and monitor fluctuations in soil organic matter and nutrient levels. The sample sites, located on agricultural land, were selected on a grid covering the entire province, in partnership with landowners. Samples were taken on a three-year cycle per site. Between 1998 and 2012, Millar reported the project sample results showed a general decline in soil organic matter. During the last three cycles, covering the years 2013-2021, the soil organic matter levels

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[123] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[124] AGFO, *Evidence*, 25 October 2022 (Sean Thomas, Research Professor, University of Toronto, As an individual).
[125] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[126] AGFO, *Evidence*, 30 November 2023 (Carla Millar, Manager, Sustainable Agriculture, Department of Agriculture, Government of Prince Edward Island).

stabilized, with no further decline. The majority of the land sampled continues to be in the 2 to 3% range of soil organic matter.[127]

Millar explained that compounding factors might have contributed to the loss of organic matter in the province's soil since 1998. For example, Millar said a decline in the livestock industry during that same period resulted in a reduction of manure inputs and in soil-building forage crops used to feed livestock. Millar added that agronomic factors—crop rotation, tillage intensity and soil erosion—have also had a cumulative effect over time.[128]

The PEI Department of Agriculture is focused on three key areas to address soil degradation in the province:

- measuring and monitoring (e.g., a soil health testing service through the PEI Analytical Laboratories; Soil Health Improvement Planning service);
- prioritizing programs and services for agricultural producers to implement beneficial farm management practices (e.g., specialized engineering services for constructing grassed terraces, berms, and waterways to slow and redirect water flow to reduce soil erosion; funding and extension support for conservation tillage, winter cover cropping and soil-building crops and perennials in rotations; a livestock strategy that targets soil health through improved grazing and increase manure amendments); and,
- working toward soil health objectives through partnerships, promotion, and collaboration, supporting and participating in soil health working groups, partnering on research projects, and planning soil health workshops (e.g., the 2021 Soil First Farming campaign).[129]

Millar told the committee that the success of the program is the regional focus; the ability to regionally design and offer BMPs that are suitable for their own climate, producers and production systems is beneficial. Millar stressed that the regionality of an approach to programming and policies is crucial.[130]

Finally, Millar said that more funding dollars would help PEI go further and would let participating producers do more because the province has strong uptake in programs: "I do think some funding helps. I also think the extension support helps as well. But funding isn't the only solution. Extension support is good too, as is coming at things with a broader kind of socio-economic lens. That is important because it just reflects that not all barriers are funding."[131]

[127] Ibid.
[128] Ibid.
[129] Ibid.
[130] Ibid.
[131] Ibid.

On the strength of PEI's soil collection program, Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University, said:

> *"In particular, Prince Edward Island has, for the last 20 years, had a georeferenced 300-site soil-quality data monitoring network. It is absolutely invaluable when you have such intensive agriculture to track changes in soil quality and soil health and construct policy based on that."*
>
> *Derek Lynch*[132]

Newfoundland and Labrador

According to AAFC, between 2018 and 2022 the top three crop and livestock commodities by average farm cash receipts for Newfound and Labrador were: dairy ($48 million), eggs ($20 million), and floriculture, nursery and sod ($9 million).[133]

Stephen Balsom, Assistant Deputy Minister, Agriculture and Lands, Department of Fisheries, Forestry and Agriculture, Government of Newfoundland and Labrador, told the committee that the province's landscape consists of complex topography, with shallow, stony and coarse to medium-textured soils which are vulnerable to water and wind erosion. Soils are acidic, naturally low in soil organic matter, and limited in nutrient retention and their ability to support crop growth.[134]

Erosion is one of the biggest soil degradation factors in Newfoundland and Labrador. Wind erosion in Newfoundland and Labrador is much less than in other provinces as many of its fields are smaller, fragmented and surrounded by forests. Balsom said recent increases in adverse weather events and various studies confirm that soil erosion is an increasingly important issue.[135]

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[132] AGFO, *Evidence*, 20 October 2022 (Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University, As an individual).
[133] Government of Canada, *Overview of Canada's agriculture and agri-food sector*.
[134] AGFO, *Evidence*, 30 November 2023 (Stephen Balsom, Assistant Deputy Minister, Agriculture and Lands, Department of Fisheries, Forestry and Agriculture, Government of Newfoundland and Labrador).
[135] Ibid.

Newfoundland and Labrador is one of the only provinces in Canada clearing land for agricultural use. Since land-clearing efforts may contribute to soil degradation, the province has promoted and adopted beneficial management practices to minimize this risk and mitigate the effects of climate change on its soils.[136]

> *"One of the successes is providing our local farmers with a report card. We have what I would call a young agriculture industry, and we're still in land-clearing mode. We're still developing new land. Providing our new farmers with an understanding of how their practices impact the soil pH — the nutrients and the carbon and nitrogen — and the beneficial practices they can use to support soil health is really the success of the program so far."*
>
> *Stephen Balsom*[137]

With funding from AAFC's Sustainable CAP and Resilient Agricultural Landscape Program, Newfoundland and Labrador has started researching and promoting the use of winter cover crops, such as alfalfa and oats, incorporating the use of legumes and green manures, and implementing crop rotation for building soil fertility. The province also conducts research on no-till farm practices to increase soil organic matter and decrease the amount of erosion. The use of wind breaks in soil erosion and wind damage is now part of their work with local farmers.[138]

Balsom reported that subscription to federally funded programs is high, as is the provincially run soil testing service to agricultural producers. There are fewer than 200 producers in the province; the larger producers who make up most of the market are subscribed. Balsom said Newfoundland and Labrador, like Prince Edward Island, could always utilize more funding, but that some funding, programs, and technologies are not scalable for smaller farms.[139]

Approximately 500 acres of forest land is cleared per year for other purposes, including agriculture. The province has considered or adopted beneficial management practices for sustainable forestry to mitigate the impacts of climate change and soil degradation. For example, Balsom said field staff and contractors assess harvested areas and strategically plan extraction trails. They also plan harvest activities and use of winter roads when harvesting in or around sensitive areas. Larger

[136] Ibid.
[137] Ibid.
[138] Ibid.
[139] Ibid.

infrastructure for water crossings, such as bridges and culverts, is incorporated to account for increased water runoff.[140]

Newfoundland and Labrador's agriculture industry is small and, in many ways, not comparable to other provincial production systems. Balsom said that support, collaboration, and capacity building for local soil research is required to adopt practices applicable to the province's local environment. Balsom added that some federally based programming may not be applicable to Newfoundland and Labrador, as the province focuses on food self-sufficiency and not commodity-based, large-scale, or export-driven agriculture.[141]

Soils Information Management

Measuring, Reporting and Verifying Soil Health

Though soil health is a topic of research around the world, the committee learned there is no global—let alone Canadian—consensus on how to measure, report and verify it.

Technicians at Environmental Material Science Ltd. show senators Mobina S.B. Jaffer and Rob Black how to assemble and install soil mapping sensors in Saskatoon, Saskatchewan.

[140] Ibid.
[141] Ibid.

David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, shared: "One of the major challenges in measuring soil health is the expense of quantifying the many aspects of soil needed to provide a complete picture of soil health." Fortunately, added Burton, emerging technologies allow rapid and inexpensive spectral characterization of soil to provide a rich characterization of the state of soil.[142]

According to David Lobb, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba, quantifying soil health as a simple index value is extremely challenging.[143] While other witnesses said that a single measure of reporting was realistic for soil health—such as soil organic matter, or soil organic carbon—they also agreed that a set of measurements, parameters, or indicators be used.

"I'm very optimistic that if we measure the same set of parameters, depending on the station, we can pick and choose which one is important in that context while still being able to communicate and compare across regions and provinces and perhaps even internationally," said Dieter Geesing, Provincial Soil Specialist, British Columbia Ministry of Agriculture and Food, Government of British Columbia.[144]

The Soil Health Institute, located in North Carolina, is doing just that. Based on recent studies, Cristine Morgan, Chief Scientific Officer, said the Institute recommends four soil health indicators:

1) soil organic carbon concentration;
2) carbon mineralization potential;
3) wet aggregate stability; and
4) available water-holding capacity.

Together with the Greenbelt Foundation, the Soil Health Institute is piloting an approach across the Golden Horseshoe region of Ontario to benchmark soil health using the above-mentioned measurements. In the pilot project, Morgan explained they provide a regional assessment of soil health, including its current state, improvements already being made with soil health practices and the potential for further improvement.[145]

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[142] AGFO, *Evidence*, 20 October 2022 (David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, As an individual).
[143] AGFO, *Evidence*, 27 September 2022 (David Lobb, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba, As an Individual).
[144] AGFO, *Evidence*, 30 March 2023 (Dieter Geesing, Provincial Soil Specialist, British Columbia Ministry of Agriculture and Food, Government of British Columbia).
[145] AGFO, *Evidence*, 13 February 2024 (Cristine Morgan, Chief Executive Officer, Soil Health Institute).

> *By measuring soils and management, we will provide producers with insight on how healthy their soil is and empower them to generate a goal on how healthy they want their soil to become.*
>
> *Cristine Morgan*[146]

Don Lobb, farmer, echoed Morgan, and added: "We must establish baselines so we can monitor trends in soil productivity, soil use and soil care. Water-stable soil aggregates should be identified as the base indicator of soil health."[147]

From a forestry perspective, Jerry V. DeMarco, Commissioner of the Environment and Sustainable Development, Office of the Auditor General of Canada, informed the committee that a more accurate, clear, and complete system for forest accounting for land use, land use change and forestry, including stored carbon in soil, would help inform decisions on what types of initiatives—including soil health—to support at the federal level.[148]

Furthermore, Kumari Karunaratne, President, Canadian Permafrost Association, emphasized that Canada lacks national permafrost leadership as there is no one organization that oversees and coordinates permafrost issues and activities for the country. "The result is that research, data, funding, and expertise are not being used efficiently and opportunities are being missed," added Karunaratne.[149]

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[146] Ibid.
[147] AGFO, *Evidence*, 29 February 2024 (Don Lobb, Farmer, As an individual).
[148] AGFO, *Evidence*, 15 June 2023 (Jerry V. DeMarco, Commissioner of the Environment and Sustainable Development, Office of the Auditor General of Canada).
[149] AGFO, *Evidence*, 23 March 2023 (Kumari Karunaratne, President, Canadian Permafrost Association).

Finally, David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, suggested that reporting on the status of soil health occur annually:

> *"[…] We not only need to measure soil health but report on the state of soil health and track our impact of agriculture and forestry practices on soil health. In the past, Agriculture and Agri-Food Canada has published The Health of Our Soils, and their environmental branch has periodically reported on a series of agri-environmental indicators. We need to make that reporting an annual requirement of our government and we need to ensure that the indicators are based on measurements of the state of the soil resource and not a product of mathematical modelling based on census of agriculture data."*
>
> *David Burton*[150]

Building Baseline Data and a National Soil Information Database

The committee heard that while a lot of soil data is being collected throughout the country, it is difficult to analyze and share this data because governments, academic institutions, organizations, and industry groups do not have a common format to collect or share soil data.[151]

Angela Bedard-Haughn, Professor and Dean, College of Agriculture and Bioresources, University of Saskatchewan, added: "We have no way to bring it together and we are losing out on major opportunities to leverage the power of big data."[152]

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[150] AGFO, *Evidence*, 20 October 2022 (David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, As an individual).
[151] AGFO, *Evidence*, 9 March 2023 (Rebecca Lee, Executive Director, Fruit and Vegetable Growers of Canada).
[152] AGFO, *Evidence*, 27 September 2022 (Angela Bedard-Haughn, Professor and Dean, College of Agriculture and Bioresources, University of Saskatchewan, As an individual).

Derek MacKenzie, Associate Professor, Department of Renewable Resources, University of Alberta, suggested that the committee recommend the establishment of a national soil health data institute:

> *"This institute would serve as a centralized hub for the collection, analysis, and dissemination of soil health data across our nation. By working closely with research institutes across the country to collate diverse datasets and employ cutting-edge technologies, such as machine learning, this institute would facilitate a deeper understanding of soil function, enabling informed decision-making for producers, land managers, researchers, and policymakers. It would also allow Canada to calculate accurate inventories of soil health parameters nationally for global reporting."*
>
> *Derek MacKenzie*[153]

In a brief, MacKenzie outlined how the proposed national soil health data institute would be governed and funded: "I have submitted a proposal outlining this institute as an endowed NGO operated by an executive committee that works in conjunction with a board of governors made up of senior representatives from agricultural producers, industry, government, and academics. The establishment of such an institute signifies our commitment to safeguarding the very foundation upon which our human health, food security and environmental sustainability depend."[154]

Bedard-Haughn made a call to action for the federal government to recognize soil as a national priority and establish a national soil information database or institute. But, where in government might those investments occur or come from? Bedard-Haughn said, historically, it should be AAFC, but also pointed out that soil information is collected through AAFC, Environment and Climate Change Canada (ECCC), and Natural Resources Canada, among other departments. Furthermore, most of the soil sampling that is currently being done in the North is part of environmental site assessments for mining and exploration. Data sharing is challenging because there is no one institute overseeing it.[155]

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[153] AGFO, *Evidence*, 7 December 2023 (Derek MacKenzie, Professor, Department of Renewable Resources, University of Alberta, As an individual).
[154] Ibid.
[155] AGFO, *Evidence*, 27 September 2022 (Angela Bedard-Haughn, Professor and Dean, College of Agriculture and Bioresources, University of Saskatchewan, As an individual).

> *"It has been really tough because it hasn't been the mandate of a federal organization — for example, Agriculture and Agri-Food Canada. We've had a loose collection of scientists, but we can't do it without funding. We need that support. We have folks with the capability, the skill, the interest, and the desire but without the resources to do it. Because it is a distributive problem, no one province wants to chip in for a national database.*
>
> *Angela Bedard-Hahn*[156]

David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, suggested this approach: "a mix of government and academic institutions in some sort of a federation, led by a champion organization, perhaps the Soil Conservation Council of Canada or the Canadian Society of Soil Science — an organization that has multiple stakeholders in industry, government and academic." Burton added that ideally multiple academic and/or government institutions would be involved in "creating a data warehousing system that has redundancy. In that way, no one organization or institution is responsible for maintaining it. It's also maintained in multiple locations so it can persist for many years."[157]

> *"It is something that needs to be central to the way we do agriculture and forestry from here on out. Who is going to fund that? I think governments have the role of funding these kinds of things, so government agencies need to be called upon to fund it. But it must be a federated approach."*
>
> *David Burton*[158]

Melissa Arcand, Soil Biogeochemist, University of Saskatchewan, pointed out that, historically, First Nations have not had strong relationships with soil data collectors and holders such as universities, governments, and the agricultural industry.[159]

"For many First Nations in Saskatchewan, the only soil data they might have access to are 60-year-old soil survey reports, which are useful for land-use planning but not for evaluating changes in soil

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[156] Ibid.
[157] AGFO, *Evidence*, 20 October 2022 (David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, As an individual).
[158] Ibid.
[159] AGFO, *Evidence*, 9 February 2023 (Melissa Arcand, Soil Biogeochemist, University of Saskatchewan, As an individual).

health," said Arcand, who also emphasized that resources are needed to support soil data collection and management by First Nations for their own lands. "Initiatives and soil data management developed through a national soil health strategy could be modelled and applied for First Nations use."[160]

Michelle Blade, Permafrost Scientist, Nunavut, and member of the Canadian Permafrost Association, told the committee that there is a lack of data coordination in Nunavut between Natural Resources Canada, the Government of Nunavut, and Inuit organizations who have been working on a long-term permafrost monitoring program in over 10 communities.[161]

Knowledge Transfer and Peer-To-Peer Soil Networks

The committee heard that it is not enough to collect soil data and house it, but that this data and research must be shared and made digestible for Canadians—especially farmers—so they can understand it and implement it.

As for that knowledge transfer, Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture, emphasized: "We need to support farmers sharing information with other farmers. It is not always the government's responsibility."[162]

The committee learned about the many peer-to-peer farmer-led soil networks that already exist throughout the country. For example, Ontario Soil Network, Ontario Soil and Crop Improvement Association and Sundance Commons are examples of grassroots organizations that have taken it upon themselves to test different beneficial soil management practices on farm and then share this information with other farmers in their regions, through events, webcasts and blogs. Regional conferences, such as the Western Canada Conference on Soil Health and Grazing held annually in Edmonton, Alberta, are another important way for farmers and ranchers to connect.

> *"Farmers need to see themselves — all ethnicities, races and genders across Canada — so it doesn't always look like such a homogenized group, which it's not. It's very diverse and increasingly more diverse."*
>
> *Brodie Berrigan*[163]

[160] Ibid.
[161] AGFO, *Evidence*, 23 March 2023 (Michelle Blade, Permafrost Scientist, Nunavut, Canadian Permafrost Association).
[162] AGFO, *Evidence*, 16 February 2023 (Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture).
[163] Ibid.

Similar grassroots organizations, such as the Manitoba Zero Tillage Research Association, Manitoba-North Dakota Zero Tillage Farmers Association and the Reduced Tillage Linkages, no longer exist in the Prairies because their funding ran out.[164] Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba, said the benefit of these organizations is they are farm-based, farmer-based, and farmer-driven: "They usually have a good uptake by farmers because the information comes from peers as opposed to a top-down approach."[165]

The committee heard that the New Brunswick Agricultural Alliance pairs young farmers with mentors. In Quebec, the Caravane Santé des sols, which is linked to AAFC's Living Labs, travels to the regions and invites producers, including Indigenous producers, to collaborate and be part of the project. The program mobilizes researchers, advisors, and producers to move towards a common goal. The concept is often managed by organizations.

> *"In summary, at the Soil Health Institute, we have evidence that adoption of soil health systems improves on-farm profitability. Successful implementation of soil health management systems requires practice and learning from other farmers who have successfully adopted them."*
>
> *Cristine Morgan*[166]

[164] AGFO, *Evidence*, 20 April 2023 (Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba); and, *Evidence*, 20 April 2023 (Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta).
[165] AGFO, *Evidence*, 20 April 2023 (Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba).
[166] AGFO, *Evidence*, 13 February 2024 (Cristine Morgan, Chief Executive Officer, Soil Health Institute).

Chapter 2: Opportunities To Use Soil-Based Methods To Mitigate Climate Change

Early Adopters

Many witnesses told the committee that the early adopters—the farmers, ranchers, and growers who first implemented regenerative and beneficial soil management practices—must be compensated fairly and recognized for their practices.

> *"These producers did the heavy lifting and on-farm experimentation required to develop many of the best management practices that contributed to the increased soil carbon sequestration from 1981 to 2016. While offsets may not acknowledge these early adopters, we do need to acknowledge and support early adopters when creating future programs to identify further best management practices. We must also celebrate these trailblazers to showcase where early adoption of best practices provided meaningful, long-term benefits — not only environmentally, but also as sound business decisions."*
>
> *Mary Robinson*[167]

Marco Valicenti, Director General, Innovation Programs Directorate, AAFC, told the committee that the On-Farm Climate Action Fund (OFCAF) allows early adopters to participate as long as it is on new land or a new piece of their property.[168]

[167] AGFO, *Evidence*, 16 February 2023 (Mary Robinson, Past President, Canadian Federation of Agriculture).
[168] AGFO, *Evidence*, 14 February 2023 (Marco Valicenti, Director General, Innovation Programs Directorate, Agriculture and Agri-Food Canada).

Several witnesses disagreed with this criterion and said that incentive programs, such as OFCAF, leave farmers, ranchers and growers feeling left behind. Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture, emphasized the importance of and need for incentives by asking: "What incentive are you putting in place when you're not recognizing the efforts of those early adopters?" [169]

> *"Manitoba farmers have embraced innovative agricultural practices to reduce emissions and enhance soil health, such as 4R uptake and the uptake in the On-Farm Climate Action Fund, or OFCAF, programs. However, factors such as crop inputs, debt, market conditions and profitability may influence the decision-making around adopting these practices, so it is key to have an incentive-based model to increase adoption. At the end of the day, you can't be in the green if you're in the red."*
>
> *Jake Ayre*[170]

Some witnesses urged the federal government to set the record straight on when the additionality principle starts, that is from what date should the early adopters be recognized and compensated for their regenerative and sustainable practices?' For example, Marty Seymour, Chief Executive Officer, CarbonRX, recommended that day zero should start at the Paris Agreement in December 2015: "All practices beyond 2015 and the signing of that accord would, for me, be the baseline for net zero."[171] Rachel Hor, Chief Operating Officer, CarbonTerra, agreed with this date, but also suggested that the federal government go as far back as 2010.[172]

[169] AGFO, *Evidence*, 16 February 2023 (Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture).
[170] AGFO, *Evidence*, 4 May 2023 (Jake Ayre, Vice President, Keystone Agricultural Producers of Manitoba).
[171] AGFO, *Evidence*, 18 May 2023 (Marty Seymour, Chief Executive Officer, CarbonRX).
[172] AGFO, *Evidence*, 18 May 2023 (Rachel Hor, Chief Operating Officer, CarbonTerra).

With respect to baselines and additionality, Kristjan Hebert, President, Hebert Group, from Saskatchewan, urged the federal government to incentivize the leaders to lead:

> *"Yes, they might have adopted zero-till 20 years ago, but they're still seeing incremental changes and they're adopting incremental practices that continue to improve. Let's incentivize the rest of the group with practice incentives to get to the point where the leaders are. You can't disincentivize the leaders to quit leading. We're trying to grow leaders in this country."*
>
> *Kristjan Hebert*[173]

Some witnesses recommended the creation of a regenerative agriculture commission:

> *"By utilizing innovative practices on our farm, we have managed to achieve the following: healthier soils, crops, and livestock; supplied beef and pork to our local communities; lowered our synthetic fertilizer up to 75% and lowered our CO_2 equivalent footprint. Yet, farmers still struggle to get paid fairly for our stewardship efforts."*
>
> *Colby Hansen*[174]

Crop Insurance

Furthermore, several witnesses told the committee that traditional crop insurance must be restructured to incentivize people for regenerative and sustainable practices rather than the current program that incentivizes people to, for example, plant canola on marginal land and then harvest the insurance.

Cedric MacLeod, Executive Director, Canadian Forage and Grassland Association, pointed out that: "[…] if we don't require some of that cross-compliance to access crop insurance, there is actually a reverse incentive toward conservation. Because if you can get crop insurance on Class 4 or Class 5

[173] AGFO, *Evidence*, 9 March 2023 (Kristjan Hebert, President, Hebert Group).
[174] AGFO, *Evidence*, 14 December 2023 (Colby Hansen, Owner/Operator, Hansen Beef).

land to grow canola or potatoes when it should actually be in permanent cover grassland, that has a very negative impact on the landscape as a whole."[175]

Stuart Chutter, Senior Policy Analyst, Agriculture Financial Services Corporation, and livestock producer from Saskatchewan, explained that crop insurance is a business risk management program with goals of food security and economic risk management for producers.[176] Chutter said that with risk management at the farm level and soil organic carbon as a metric, there is alignment in those incentives, so there is opportunity, without compromising the goal of primary financial risk management for the producer.[177]

For instance, in a soil analysis for crop insurance, Chutter used an aggregated data set of soil organic carbon across Alberta that was made available through funding by the Sustainable CAP, which then funded Food Water and Wellness in Calgary, to map soil organic carbon at the field level for the entire province of Alberta. Soil mapping was key for Chutter's analysis:

> *"My message today is that a key role for federal policy is funding that sort of soil mapping and data aggregation so we can run our analyses and make good data-driven decisions. We are dependent upon those sorts of data sets to complete our analyses."*
>
> *Stuart Chutter*[178]

[175] AGFO, *Evidence*, 22 September 2022 (Cedric Macleod, Executive Director, Canadian Forage and Grassland Association).
[176] AGFO, *Evidence*, 9 November 2023 (Stuart Chutter, Senior Policy Analyst, Agriculture Financial Services Corporation).
[177] Ibid.
[178] AGFO, *Evidence*, 9 November 2023 (Stuart Chutter, Senior Policy Analyst, Agriculture Financial Services Corporation).

How would a lending institution look at an insurance program that bases insurance risk on soil health? Justine Hendricks, President and Chief Executive Officer, Farm Credit Canada (FCC), responded that FCC has been approaching it through the incentive to continue these best practices:

> *"[…] whether you're a livestock or crop producer and considering exactly what your unique requirements are to contribute to the best output, we customize those incentive programs to make sure that we can respect the level of every subsector. As a result, we'll give back a percentage against interest paid on their working capital facilities, which rewards the good behaviour."*
>
> *Justine Hendricks*[179]

Todd Klink, Executive Vice-President and Chief Marketing Officer, Farm Credit Canada, added that FCC has tried to look for industry best practices, and where industry sees the opportunities within their subsector, whether that be crops, beef, or other commodities: "Then the question is how we work with those groups to partner and work with their growers who grow those crops to move forward this discussion that ultimately ends with best management practices and improving soil health."[180]

Creating A Viable Soil-Based Carbon Marketplace For Agriculture

While the 1984 report of the committee considered the economics of soil conservation, the idea that soil health is a commodity was not on the horizon in the 1980s as it is now.[181]

Canada has a regulated/compliance and voluntary/non-compliance carbon marketplace. The ISO 14064 is the main standard, which is used by Alberta and ECCC when designing protocols.

Graham Gilchrist, Chief Executive Officer, Biological Carbon Canada, told the committee that soil health must be treated as a commodity and that "Canada needs a carbon regulator for the buying and selling of certificates, and a market regulator to keep Canada on pace with the people in our competition—the United States and our other trading partners around the world."[182] The United States, for example, recently earmarked US$300 million of new money on carbon measurement and verification in agriculture. "Soil-based Canadian carbon is already in our marketplace, […], but it

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[179] AGFO, *Evidence*, 9 November 2023 (Justine Hendricks, President and Chief Executive, Farm Credit Canada).
[180] AGFO, *Evidence*, 9 November 2023 (Todd Klink, Executive Vice-President and Chief Marketing Officer, Farm Credit Canada).
[181] AGFO, *Evidence*, 23 November 2023 (Graham Gilchrist, Chief Executive Officer, Biological Carbon Canada).
[182] Ibid.

is a[n unregulated] commodity. Canada's carbon marketplace deserves to have the legislation it needs to grow and thrive."[183]

Marty Seymour, Chief Executive Officer, CarbonRX, suggested that the federal government step in to facilitate the growth of the voluntary carbon credit market in Canada:

> *"It might be counterintuitive that the government might help to support the voluntary market, but it allows private-sector money to flow into the Canadian food system. It's a great vehicle to help finance and move producers along that change curve. The federal and provincial government carbon schemes actually create market confusion. Global buyers want nature-based carbon credits, which Canada is rich in, and agriculture and forestry offer this great opportunity for carbon removal."*
>
> *Marty Seymour*[184]

Furthermore, Seymour recommended the creation of "an industry-owned and industry-driven carbon economy—and I don't mean Canadian-industry-owned; I'm talking about international partners and members as well."[185]

Similarly, witnesses from CarbonTerra expressed their interest in developing a voluntary or compliance carbon credit market that could be endorsed by the federal government, where a carbon credit has value, even if it starts to trade in Canada and is then adopted globally:

[183] Ibid.
[184] AGFO, *Evidence*, 18 May 2023 (Marty Seymour, Chief Executive Officer, CarbonRX).
[185] Ibid.

> *"We need the federal government to work with the provinces instead of this mishmash of one province wants to do this, and the feds want to do something else. We need a coherent system that we can almost bank on, where we can say that now we have a path, let's build something. Right now we're guessing. We're trying to steer it, but we're just a small company. We need the government to step in and take some leadership."*
>
> *Jason Mann*[186]

Marty Seymour added: "If we've been zero-tilling in Saskatchewan for 20 years, and we agree we will not convert that land to tilled land, there may be a carbon conversation in that. It's a nuance in the recipe. We've been so focused on rewarding for the practice. Maybe we're missing an obvious one to say, "Wait a minute, if we don't convert and release 20 tonnes of carbon, that's carbon credit by definition."[187] Similarly, Jocelyn Velustuk said: "If there is a value to carbon and farmers know that, farmers will keep adding to that."[188]

Witnesses pointed out additional barriers to widespread adoption of this type of market. For example, Robin Woodward, Director, Carbon Asset Solutions, mentioned the inability to measure anything, and to get to a place in a market where you can have confidence globally that what is being delivered to market has value.[189]

Martin Caron, President and CEO of the Union des producteurs agricoles du Québec, suggested a compliance declaration, a practice that exists in Quebec, but that could be used at the federal level: "The producer declares how long he has been carrying out sequestration activities or other work that has been beneficial. Then the advisers can validate the farm's work. There are ways of simplifying things and recognizing those pioneers who have really contributed. I think of the organic producers, who have done a lot of work on this."[190] Caron believes that monetizing soil carbon sequestration as a tool to mitigate global climate change could be implemented at a relatively low cost per tonne of CO_2 equivalent with co-benefits such as increased fertility, cleaner water and greater farm product profitability and productivity.[191]

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[186] AGFO, *Evidence*, 18 May 2023 (Jason Mann, Chief Executive Officer, CarbonTerra).
[187] AGFO, *Evidence*, 18 May 2023 (Marty Seymour, Chief Executive Officer, CarbonRX).
[188] AGFO, *Evidence*, 9 March, 2023 (Jocelyn Velestuk, Farmer, Grain Growers of Canada).
[189] AGFO, *Evidence*, 23 November 2023 (Robin Woodward, Director, Carbon Asset Solutions).
[190] AGFO, *Evidence*, 16 February 2023 (Martin Caron, President and CEO, Union des producteurs agricoles).
[191] Ibid.

Chapter 3: The Ecological Goods and Services of Native Grasslands and Grazing Animals

The committee learned that nature-based climate solutions could help the Government of Canada achieve its climate change mitigation commitments by intentionally increasing carbon sequestration or reducing emissions from natural systems such as grasslands.

Grasslands and rolling hills at the South Porcupine Ranch in Willow Creek, Alberta.

"An important one to mention is the carbon that is sequestered and securely stored in the soil and root networks of Prairie grasslands. A 2021 study by several collaborators, including conservation organizations, academic institutions, Agriculture and Agri-Food Canada and Natural Resources Canada, indicates that protecting our native grasslands is the single most effective nature-based solution available to Canada for mitigating climate change over the next 20 years," said Melanie Bos, Agriculture Policy Manager, Nature Conservation of Canada.[192]

Grasslands absorb and store carbon, provide protection from flooding and drought, purify water, and provide habitat for hundreds of species.[193] Canada's grasslands play an important role in GHG reduction efforts and increasing carbon sequestration.

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[192] AGFO, *Evidence*, 13 February 2024 (Melanie Bos, Agriculture Policy Manager, Nature Conservancy of Canada).
[193] Ibid.

Al Mussell, Director, Research, Canadian Agri-Food Policy Institute told the committee: "Agriculture contributes about 8% of Canada's greenhouse gas emissions, split about evenly between cropping and animal agriculture systems, which both occur on soils — living, dynamic environments consisting of mineral fractions, degrading biomass and microbes. Agricultural plants are about 40% to 50% carbon, typically with equal growth above and below the soil surface."[194]

> *"It's estimated that the roughly 14.3 million acres of native grassland in Saskatchewan are storing between 22 and 86 tonnes of carbon per acre. When you combine sequestration for annual crop land sequestration and the sequestration from grasslands, carbon sequestered by Saskatchewan soils largely offsets our agricultural emissions from cropping, livestock and on-farm fuel combined."*
>
> *Rick Burton*[195]

[194] AGFO, *Evidence*, 25 October 2022 (Al Mussell, Director, Research, Canadian Agri-Food Policy Institute).
[195] AGFO, *Evidence*, 30 March 2023 (Rick Burton, Deputy Minister of Agriculture, Government of Saskatchewan).

Stuart Chutter, Senior Policy Analyst, Agriculture Financial Services Corporation, and rancher, explained the effects of grazing cattle on soil carbon stocks in grasslands:

> *"In spring, across the grasslands in Canada, plants are greening up and starting to photosynthesize, and they'll grow and photosynthesize and put carbon down into the ground while they're doing that. Then, like any species, they want to ensure the next generation, so they'll become reproductive, stop photosynthesizing and put their energy into forming a seed, and that life cycle is over.*
>
> *But if at just that time, before grass is going to go to seed, we bring in a giant herd of cows, they're going to take a big bite of that grass. Then that plant, to go to seed and meet its goal, needs to photosynthesize again and put carbon in the ground again. If we take those cows off the land, that plant will do that, and once it's ready to go to seed, we can bring that big herd of cows back in to take another bite. That's how we can triple or quadruple that life cycle of photosynthesis and significantly increase our ability to sequester carbon on grazing lands."*
>
> *Stuart Chutter*[196]

Andrea Brockelbank, Executive Director, Beef Research Council, said that rotational, or regenerative, grazing involves moving animals into a smaller area, usually with more fencing, and then intensely grazing and moving them off pasture to allow it to rest before moving them back on.[197]: "This is the way the buffalo used to do it on the Prairies. […] This is how grass responds well, really thrives and contributes to biodiversity and those other things."[198]

The committee also heard that extensification of the agricultural land base will generate episodic greenhouse gas emissions from land conversion to agriculture and exacerbate biodiversity concerns. A related worry is that high crop prices will stimulate conversion of grassland used for grazing animals to annual crops.

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[196] AGFO, *Evidence*, 9 November 2023 (Stuart Chutter, Senior Policy Analyst, Agriculture Financial Services Corporation).
[197] AGFO, *Evidence*, 3 November 2022 (Andrea Brockelbank, Executive Director, Beef Research Council).
[198] Ibid.

Al Mussell said that new research is improving the understanding that farm animals, especially ruminants such as cattle, sheep, and goats, are essential to the long-term health of soils:

> *Methane emissions from livestock sources have been a concern. However, recent research from Oxford and the University of California, Davis has shown that the methane emissions from ruminant animals are fundamentally different from the methane emissions due to the extraction and burning of fossil fuels. In fact, a stable ruminant population actually leads to a stable level of methane in the atmosphere.*
>
> *This is an important finding, as grasslands are a critical carbon sink, are critical to biodiversity, and the economic retention of grasslands depends upon grazing animals."*
>
> *Al Mussell*[199]

Ronald Bergen, Science Director, Beef Cattle Research Council, Canadian Cattle Association, added that grazing practices that work in one region may not work in another. "Research must be tested in a wide variety of different environments because cattle are raised throughout the country," said Bergen. "Long-term grazing research is critical, in case a project coincides with a three-year drought or heavy precipitation, which would not adequately reflect what happens over a 10, 15, 30-year time span."[200]

Witnesses told the committee that extension research is needed, as well as infrastructure support for producers, including fencing and water systems.

On its fact-finding mission to Western Canada, the committee learned firsthand at South Porcupine Ranching Ltd. that ranchers in Alberta and Saskatchewan are trying to develop carbon credit trading markets for the preservation of natural grasslands and for turning marginal land back to forage under the Grasslands Capital X pilot program.

[199] AGFO, *Evidence*, 25 October 2022 (Al Mussell, Director, Research, Canadian Agri-Food Policy Institute).
[200] AGFO, *Evidence*, 23 November 2023 (Ronald Bergen, Science Director, Beef Cattle Research Council, Canadian Cattle Association).

Bill Newton, Governor, Western Stock Growers Association and rancher, told the committee that it is possible to incentivize grassland conservation through a marketplace:

> *"If we have a market that rewards this balanced suite of ecological function, producing a variety of ecological goods and services — everything from biodiversity to food, carbon capture and water capture, as well as an effective energy cycle where the nutrients are cycling back onto the land —then I certainly think it's possible to incentivize the conservation of grasslands through a marketplace."*
>
> *Bill Newton*[201]

Senator Rob Black, right, speaks with Bill Newton at Mr. Newton's South Porcupine Ranch in Willow Creek, Alberta.

[201] AGFO, *Evidence*, 23 November 2023 (Bill Newton, Governor, Western Stock Growers Association).

Chapter 4: The Role of Agroforestry and Its Impacts on Soil Health

Introduction

Agroforestry is a unique land management approach that intentionally blends agriculture and forestry to enhance productivity, profitability, and environmental stewardship. The committee learned that agroforestry is a key tool for Canada's farmers, ranchers, woodland/woodlot owners, Indigenous communities, and others who want to use sustainable strategies that enhance agricultural practices and protect soil, water, and air.

Nadir Erbilgin, Professor and Chair, Department of Renewable Resources, University of Alberta, told the committee that agroforestry is a simple way of improving soil health. "[Agroforestry] really optimizes the numerous benefits arising from the biophysical and even biochemical interactions among the crops and livestock with the trees." [202] Furthermore, E.P. (Ted) Taylor, Soil Resource Specialist, Soil Resource Group, explained that the main linkages of agroforestry to soil health are: long-term cover of soils, continuous and substantive additions of organic matter, and, carbon sequestration.[203]

Overall, the committee heard that agroforestry has a positive long-term impact on soil health in Canada when properly planned and managed.

"Farmers Like Trees": Types of Agroforestry Systems in Canada

Agroforestry is practiced in different ways throughout Canada and varies according to region, climate, as well as the specific goals of landowners.

In a written brief, Raju Soolanayakanahally, Research Scientist, Agriculture and Agri-Food Canada (AAFC), outlined the five most common agroforestry practices in Canada:

1. **shelterbelts/windbreaks**: Rows of trees or shrubs planted around or within fields and livestock facilities to protect crops, livestock and soil from wind and snow accumulation while also improving biodiversity.
    - British Columbia (Peace River region), Prairies (Alberta, Manitoba, Saskatchewan) and Great Lakes region.

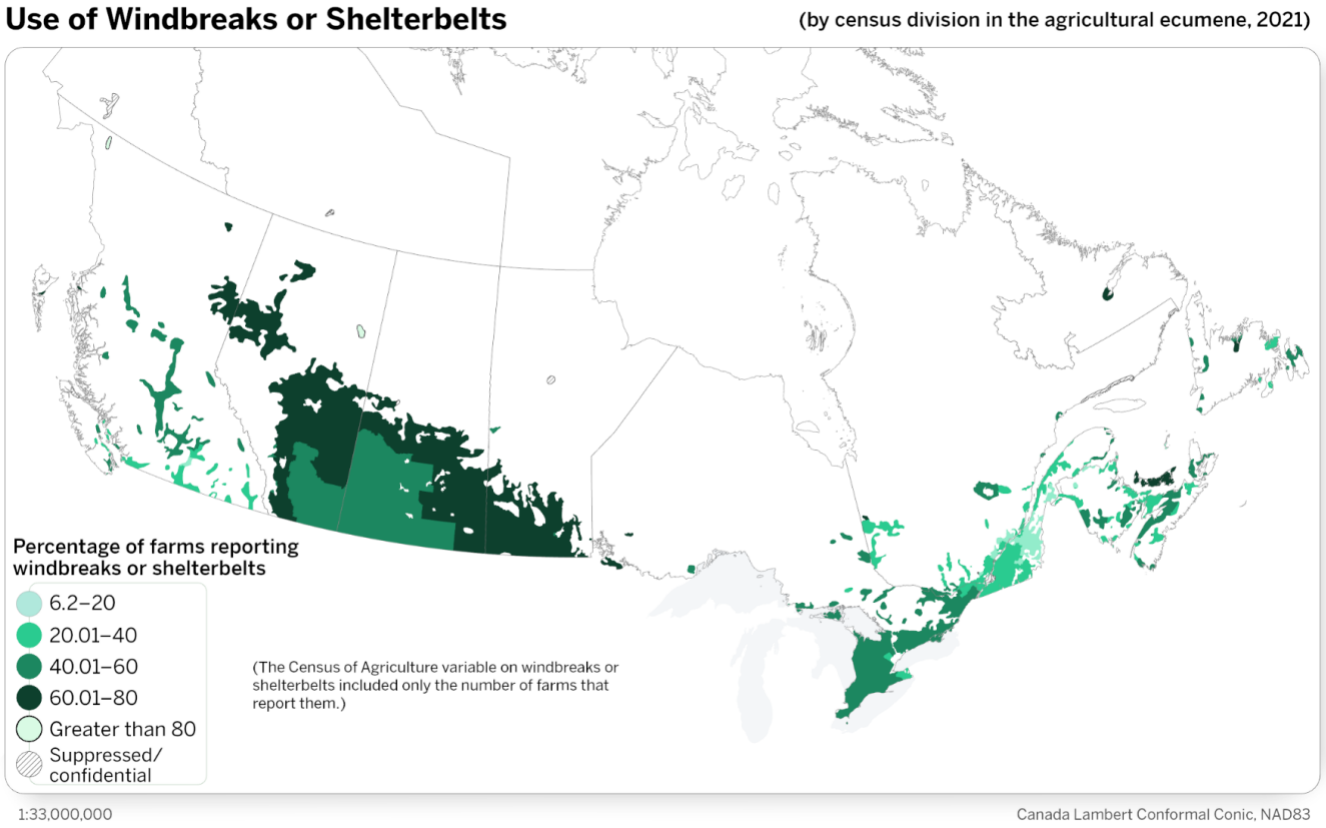
[202] AGFO, *Evidence*, 27 September 2022 (Nadir Erbilgin, Professor and Chair, Department of Renewable Resources, As an individual).
[203] AGFO, *Evidence*, 2 November 2023 (E.P. (Ted) Taylor, Soil Resource Specialist, Soil Resource Group).

2. **riparian tree buffers**: A strip of forested land adjacent to a flowing body of fresh water (e.g., stream, lake, wetland). Physically separates agricultural activities from sensitive aquatic areas.
   - Nova Scotia, Ontario, Prince Edward Island, Quebec.
3. **alley cropping/tree intercropping**: A practice in which crops and trees are interplanted throughout a field. Arable crops are grown between rows of high-value trees to maximize benefits and productivity per unit area of land.
   - New Brunswick, Ontario, Quebec.
4. **silvopasture**: The intentional integration of pasture, livestock, and trees. Provides shade and winter shelter for livestock; increases pasture acreage and diversity, use of existing farm woodland, forage availability during droughts; diversifies livestock diet; and improves animal welfare.
   - British Columbia (interior) and Quebec.
5. **farm woodlands or woodlots**: Private enterprises use this farming practice to grow non-timber forest products on private lands, supplement family income, and allow biodiversity to re-establish within woodlands.
   - Ontario, Quebec.[204]

According to Statistics Canada Census of Agriculture, in 2021, the most significant areas with windbreaks or shelterbelts are in the Prairies, exhibiting between 40% and 80% with two small pockets in the northern part of the provinces having more than 75%. Central and Atlantic Canada range between 6.2% and 60% with the lowest numbers in southern Quebec, the higher numbers mostly in southern Ontario and the highest in Prince Edward Island (see Figure 28).

[204] Raju Soolanayakanahally, Research Scientist, Agriculture and Agri-Food Canada, Brief submitted to AGFO, 2 November 2023.

Figure 28 – Percentage of Farms Reporting the Use of Windbreaks or Shelterbelts in Canada

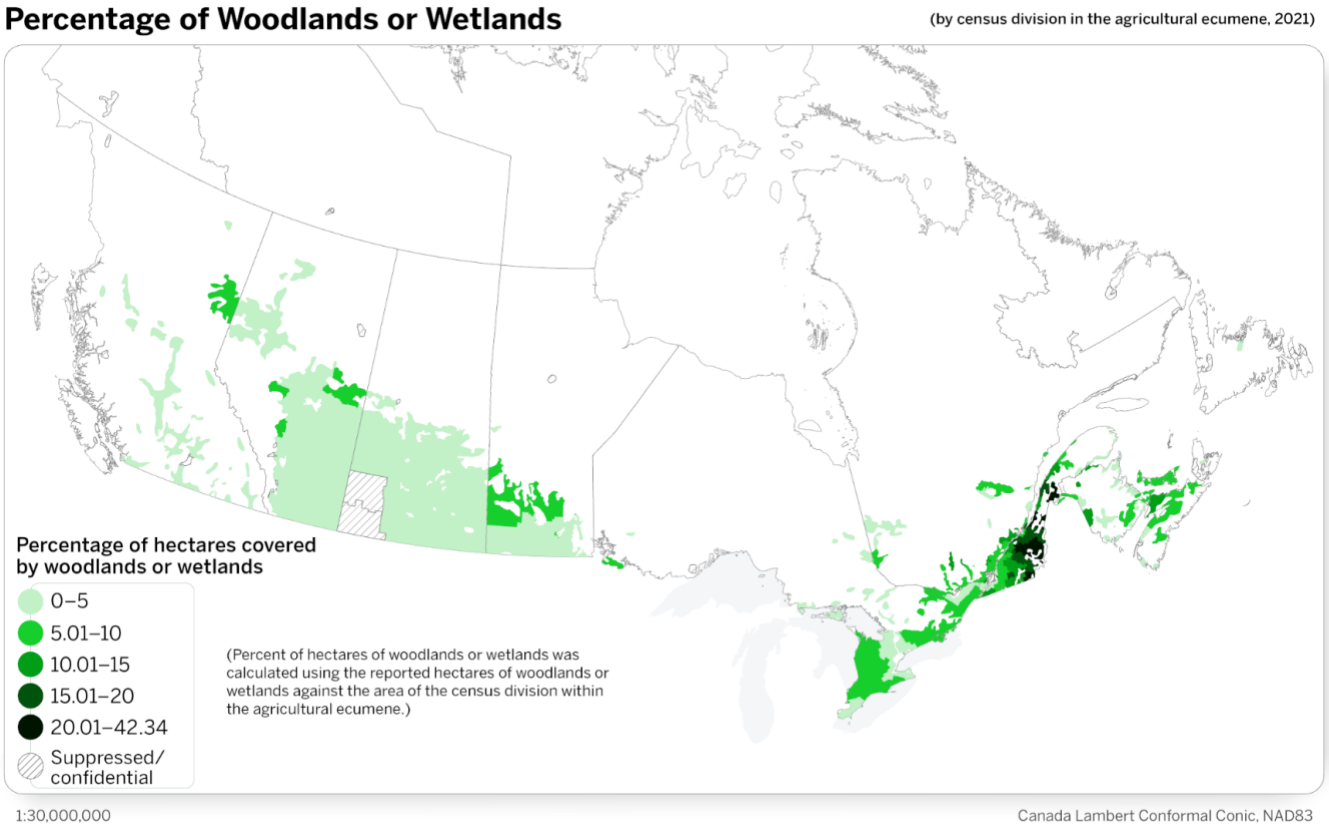


Note: The Census of Agriculture variable on windbreaks or shelterbelts included only the number of farms that reported them.

Sources: Map prepared in 2024 using data obtained from Statistics Canada, "Table 32-10-0369-01: Land practices and land features, Census of Agriculture, 2021," Database, accessed 12 March 2024; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under *Statistics Canada Open Licence*.

The 2021 Census of Agriculture reported that British Columbia, the Prairies, and Ontario exhibit 10% or less of hectares covered by woodlands or wetlands, while data in Atlantic Canada reveal one region in Nova Scotia on the border of New Brunswick with up to 15%. Southern Quebec, south of the St. Lawrence, exhibits some of the highest values up to 42.34%, as illustrated in Figure 29.

Figure 29 – Percent of Hectares Covered by Woodlands or Wetlands in Canada



Note: Percent of hectares was calculated using the reported hectares of woodlands or wetlands with only the area of the census division within the agricultural ecumene.

Sources: Map prepared in 2024, using data obtained from Statistics Canada, "Table 32-10-0249-01 Land use, Census of Agriculture, 2021," Database, accessed 12 March 2024; and Statistics Canada, *2021 Census – Boundary files*. The following software was used: Esri, ArcGIS Pro, version 3.2.2. Contains information licensed under the *Statistics Canada Open Licence*.

Economic and Environmental Benefits

In terms of economic benefits, the committee learned that agroforestry practices can help farmers and ranchers increase their crop yields and reduce energy, fertilizer, heating, and snow removal costs.

Agroforestry also allows farmers and ranchers to develop specialty agricultural and wood products, which can provide diverse income streams and increased wealth in rural communities. Witnesses listed many examples of specialty agricultural products such as honey, maple syrup products, medicinal herbs, mushrooms, nuts, and wild berries.

Witnesses also highlighted examples of specialty wood products, including biomass for energy; firewood, sawlog timber, veneer, utility hardwoods for pallets; conifers for fence posts; on-farm use woods for corrals, fences, wagon building; and recreational use woods for decks or fences, among others.

In a written brief, Raju Soolanayakanahally reported that a recent quantification of carbon stocks with agroforestry systems in central Alberta from hedgerows, shelterbelts, and silvopastures revealed that 699.9 million tons (Mt) of carbon were stored across 9.5 million hectares (Mha) of land and valued at $102.7 billion based on a Canadian carbon tax rate of $40 per ton of CO_2 equivalent in 2021."[205]

The committee also heard about the many environmental benefits and essential ecosystem services that agroforestry and woody vegetation offer, including:

- clean air and water;
- climate change mitigation by sequestering carbon dioxide from the atmosphere and reducing GHG emissions;
- soil rehabilitation;
- crop diversification which reduces risks associated with monoculture soil degradation, pests, and disease; and,
- improved biodiversity by providing wildlife habitat, nesting sites for birds, refuge for beneficial insects and pollinators, and habitat protection for fish and other aquatic ecosystems.

Specifically, agroforestry systems such as shelterbelts increase crop yields by providing wind protection and improving water-use efficiency. Riparian buffers help to stabilize eroding banks and shorelines; reduce sediment flow into water bodies to protect water quality; and absorb nutrients

[205] Raju Soolanayakanahally, Research Scientist, Agriculture and Agri-Food Canada, Brief submitted to AGFO, 2 November 2023.

(nitrogen, phosphorous) and pesticide compounds. Silvopasture can offset methane emissions from cattle through the carbon-capture capabilities of trees and shrubs.[206]

Raju Soolanayakanahally added that through the integration of agroforestry, we can further enhance the physical, chemical, and biological properties of our soils, providing essential environmental services such as:

- using trees with deep roots to bring up vital nutrients for crops and vegetation, and,
- adding organic matter to the soil through litter to support soil biodiversity and functions such as nutrient cycling, soil health and land productivity.[207]

Several witnesses told the committee that farmers and ranchers face many barriers to adopting agroforestry practices such as: accessing suitable tree species, costs for equipment, implementation, and planting; and, weed management.

Witnesses also described the barriers that stem from the lack of government funding for agroforestry such as:

- lack of crop insurance for growing trees;
- lack of a viable carbon market for trees sequestrating carbon;
- lack of government funding and research for agroforestry;
- lack of a strategic framework or policy for agroforestry; and,
- lack of Indigenous knowledge transfer on agroforestry practices.

The committee also heard that there is a jurisdictional dilemma with regards to who is responsible for agroforestry on agricultural land in Canada. Ken Van Rees, Professor Emeritus, Forest Soils, University of Saskatchewan, said that a clear outline for agroforestry is needed.

[206] Ibid.
[207] Ibid.

> *"During my 20 years of doing this research, no one at Agriculture Canada and Natural Resources Canada wanted to take responsibility for growing trees on agricultural land. We need to sort this out. That is why the PFRA [Prairie Farm Rehabilitation Administration] Shelterbelt Centre was a key piece to doing that."*
>
> *Ken Van Rees*[208]

The PFRA produced millions of trees onsite and provided them for free to landowners across the prairies for planting.

In a similar vein, Kevin Boon, General Manager, B.C. Cattlemen's Association, pointed out a jurisdictional dilemma regarding agroforestry in British Columbia:

"In essence, we utilize it and need to manage it as agroforestry. But the responsibility for that, because it is Crown land, falls on the provincial government, and much of it is managed by regulation and not necessarily by science. We see some problems with that."[209]

> *"The problem is everybody is looking for a quick fix. Trees take a while to grow and be established. We need to move out of this mentality of a quick fix and look at agroforestry's long-term value. Agriculture Canada has not been funding agroforestry nearly to the extent that it should be."*
>
> *Paul Renaud*[210]

Paul Arp said that soil mapping at one-metre resolution is the solution as better maps allows people to plan better: "[…] mapping the land at the one-meter resolution allows you to see where to place what parts of the agroforestry component that you wish. You would know beforehand if you have land that is suitable for this and suitable for that."[211]

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[208] AGFO, *Evidence*, 2 November 2023 (Ken Van Rees, Professor Emeritus, Forest Soils, University of Saskatchewan, As an individual).
[209] AGFO, *Evidence*, 2 November 2023 (Kevin Boon, General Manager, B.C. Cattlemen's Association).
[210] AGFO, *Evidence*, 2 November 2023 (Paul Renaud, Chief Executive Officer, The Lanigan Group).
[211] AGFO, *Evidence*, 2 November 2023 (Paul Arp, Professor, Forest Soils, Forestry and Environmental Management, University of New Brunswick, As an individual).

Paul Arp explained further: "If you know where to grow which trees and where to establish which crops for agriculture production, and not only that but also how to deal with the wetland issue — not so much the protection of the wetland but more generally the protection of biodiversity or the expansion into biodiversity goals — it would be fundamental to keep us sustainable and self-sufficient." [212]

Paul Renaud agreed about the need for enhancing soil mapping:

> *"Hold AAFC and ECCC accountable for answering this question: Why is it that we do not know the net carbon footprint of agriculture in Canada? That would require them to understand the amount of land covered by trees, possibly to expand the wonderful program that Dr. Arp is doing in terms of mapping land use across Canada, not just in New Brunswick, so that we can get facts that we can put on the table to understand and make informed decisions."*
>
> *Paul Renaud*[213]

Renaud also suggested that the Government of Canada redirect the carbon tax revenue that is collected from carbon emitters and use it to incentivize those who sequester carbon.

> *"Can you imagine if we started paying that dairy farmer in Perth $100,000, how his neighbours and other dairy farmers in Canada would react? They would jump on board. They would want more trees; they would look at ways to cut their emissions. This would generate such an amazing transformative effect that it would be astounding."*
>
> *Paul Renaud*[214]

[212] Ibid.
[213] AGFO, *Evidence*, 2 November 2023 (Paul Renaud, Chief Executive Officer, The Lanigan Group).
[214] Ibid.

Chapter 5: Soil Pollution and Contamination

Introduction

The committee learned that soil pollution affects the food we eat, the water we drink and the air we breathe, and that most people do not understand how significant a problem soil pollution is.

> *"There are 20 million contaminated sites across the world. On average, there are 1.72 contaminated sites per 100,000 inhabitants. […] In Canada, there are approximately 20,000 normal industrial sites and about 250,000 sites that arise out of abandoned oil and gas wells. Whether or not you consider those true contaminated sites is another issue."*
>
> *Steven D. Siciliano*[215]

Ravi Naidu, Chief Executive Officer and Managing Director, *crcCARE*, explained to the committee that healthy soils act as a natural buffer against the spread of pollutants and disease.[216] Biodiverse soils form a resilient barrier against pathogens, preventing their transmission to plants, animals and humans. Healthy soils are also more resilient and able to retain and immobilize agrochemical pollutants entering the ecosystem.

As Figure 30 illustrates, soils act as a sponge by holding and filtering water, directly influencing the quality of water resources, and protecting communities from waterborne diseases and pollution. Any pollutants entering the soil system impact soil health, and ultimately the environment, food, and human health.

[215] AGFO, *Evidence*, 7 December 2023 (Steven D. Siciliano, Professor, Department of Soil Science, University of Saskatchewan, As an individual).
[216] AGFO, *Evidence*, 6 February 2024 (Ravi Naidu, Chief Executive Officer and Managing Director, *crcCARE*).

Figure 30 – The Effects of Soil Contamination on the Environment, Food and Human Health

Source: Food and Agriculture Organization of the United Nations, "Communication material," *Global Soil Partnership*.

Naidu told the committee that while Canadian soils are generally well maintained with minimal tillage, challenges remain, including cadmium and diffused pesticide contamination.[217]
Steve Siciliano, University of Saskatchewan, added that human activities impact ecosystems and

[217] AGFO, *Evidence*, 6 February 2024 (Ravi Naidu, Chief Executive Officer and Managing Director, crcCARE).

these ecosystems, in turn, impact human health primarily through the release of direct pollutants such as hydrocarbons or excess fertilizer, and through compaction and sealing off the surfaces.[218]

Federal Initiatives

The committee learned that, over the last 30 years, the federal government has undertaken some strong initiatives regarding soil pollution. For example, the soil health group at ECCC is a world-leading institute for the development of soil ecotoxicity testing species and the frameworks for it. Health Canada's contaminated soils advisory group provides expert support in human health assessment arising from soil pollutants. However, Steven D. Siciliano, Professor, Department of Soil Science, University of Saskatchewan, also said some emerging policy gaps are challenging Canada's existing policy framework, one of which has to do with contaminated sites. Siciliano explained that contaminated soils are a provincial jurisdiction, unless they are on federal lands or other territories, or they impact waterways. The policies and frameworks that were developed never envisioned situations where contaminated soils would be impacting the atmosphere.[219]

Siciliano said: "Over the last 20 years, a scientific consensus has emerged about the importance of contaminated systems in methane and nitrous oxide release and mitigation. This is currently living in a policy no-man's-land. Nobody knows who should be managing that."[220]

Siciliano suggested that the federal government take the following steps to benefit the health of Canadians from contaminated soils:

- paving roads throughout Canada;
- updating the guidelines for polycyclic aromatic hydrocarbons (PAHs) such as pyrene and phenanthrene, so that owners of contaminated sites can manage the ecosystem to better restore it (earthworms, etcetera); and,
- re-envision the current chemical criteria to restore and enhance ecosystem health.[221]

[218] AGFO, *Evidence*, 7 December 2023 (Steven D. Siciliano, Professor, Department of Soil Science, University of Saskatchewan, As an individual).
[219] Ibid.
[220] Ibid.
[221] Ibid.

Mining and Oil/Gas Industries

An overhead view of Meadowbank Mine in Nunavut.

Witnesses told the committee about problems stemming from the mining and oil/gas industries. For instance, decommissioned gas stations, lead paint and lead in gasoline can pollute soil and, because they are persistent pollutants, they still cause issues even when they have been banned. Remediation technology is available; however, Subhasis Ghoshal, Professor, Civil Engineering and Director, Trottier Institute for Sustainability in Engineering and Design, McGill University, said there is a lack of awareness and a lack of data on where contaminated sites are located.[222] Overall, there is no data on, nor a uniform definition of, contaminated soils.

On the reclamation of contaminated agricultural sites in Alberta from oil and gas leaching, the committee learned that disrupting the site can bring on other contagions or pathogens. Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta said: "There are a lot of other issues other than soil health that we have to deal with on a regular, annual basis — things like weeds and invasives, et cetera, and moving them off sites. There's also the movement of pathogens like

[222] AGFO, *Evidence*, 15 February 2024 (Subhasis Ghoshal, Professor, Civil Engineering and Director, Trottier Institute for Sustainability in Engineering and Design, McGill University, As an individual).

clubroot, which is a soil-borne pathogen that can move off-site. Those are the activities that we need to work more on, and on a regular, everyday basis, too."[223]

Francis Zvomuya, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba, told the committee that high levels of lead have been found in the urban soils that Canadians use for their vegetable gardens. Lead pollution comes from the legacy source of leaded gas: "For most root crops like carrots or potatoes, it's stuck on the outside or the skin of the carrot. It's always good practice to peel carrots and potatoes before you consume them. For green vegetables, a lot of it is not coming from the ground through the roots. It's coming from the dust that's contaminated with lead. Making sure that you wash those green vegetables thoroughly will also help reduce the risk of lead poisoning."[224]

Agriculture

In agriculture, the committee heard that pesticides, nutrients, chemicals, and antibiotics are well regulated by the Pest Management Regulatory Agency. Daniel Alessi, Professor and Encana Chair in Water Resources, Department of Earth and Atmospheric Sciences, University of Alberta, said that support for education for farmers on the application of herbicides, pesticides, natural amendments, as well as proper management of fertilizer use, is a worthy endeavour to explore and expand.[225]

Gordon Price, Professor, Department of Engineering, Faculty of Agriculture, Dalhousie University, added: "We put a lot of responsibility on farmers to be environmental stewards, and that's not a mantle they necessarily started with. They are business people and are generational families that are practising the production of food. We put a lot of responsibility on their shoulders."[226]

Two significant sources of materials with potential benefits to soil health originate from the management of urban organic wastes, specifically food wastes and biosolids. Price stated that, many organic residues entering soils originate from outside of agriculture. As a result, these residues carry "the footprint of Canadians' daily activities, and can have a direct effect on the health of soils, good and bad, and ultimately on human health." [227]

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[223] AGFO, *Evidence*, 20 April 2023 (Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta).
[224] AGFO, *Evidence*, 15 February 2024 (Francis Zvomuya, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba, As an individual).
[225] AGFO, *Evidence*, 15 February 2024 (Daniel Alessi, Professor and Encana Chair in Water Resources, Department of Earth and Atmospheric Sciences, University of Alberta, As an individual).
[226] AGFO, *Evidence*, 15 February 2024 (Gordon Price, Professor, Department of Engineering, Faculty of Agriculture, Dalhousie University, As an individual).
[227] Ibid.

Zvomuya told the committee about emerging contaminants such as antibiotics: "Some of the research we did in Alberta was looking at the antibiotics that are fed to animals. Then, we apply the manure on agricultural land as a good source of nutrients — what happens to those antibiotics in light of the superbugs or the development of antibiotic resistance?"[228]

Witnesses advocated for more research on and awareness of:

- nano fertilizers, which have less adverse effects on soil;
- the overall risks caused by microplastics on human health;
- the origins of microplastics from domestic wastes;
- the overuse of plastic mulch in fruit and vegetable production, and how banning plastic bags would decrease microplastic pollution;
- alternatives to conventional pesticides such as biochar, a carbon-negative soil amendment, which has been shown to improve soil health and fertility;
- the proper management of waste, sewage, and water; and,
- the impacts of pharmaceutical product pollution and per- and polyfluorinated substance compounds on soil.

Ghosal said that there is lack of federal guidance on how to clean up agricultural soils, especially with emerging contaminants such as pharmaceuticals and the per- and polyfluoroalkyl substance compounds.[229]

[228] AGFO, *Evidence*, 15 February 2024 (Francis Zvomuya, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba, As an individual).
[229] AGFO, *Evidence*, 15 February 2024 (Subhasis Ghoshal, Professor, Civil Engineering and Director, Trottier Institute for Sustainability in Engineering and Design, McGill University, As an individual).

Daniel Alessi, Professor and Encana Chair in Water Resources, Department of Earth and Atmospheric Sciences, University of Alberta, described the opportunities, such as resource recovery pathways, that exist in the face of challenges related to soil contamination:

> *"For example, legacy sources of soil contamination such as produced water from oil and gas wells, or fly ash piles from coal combustion to generate electricity contain critical minerals. Researchers in government, industry and academia are developing methods to extract these metals, turning what was a liability to soil and water health into a resource."*
>
> *Daniel Alessi*[230]

[230] AGFO, *Evidence*, 15 February 2024 (Daniel Alessi, Professor and Encana Chair in Water Resources, Department of Earth and Atmospheric Sciences, University of Alberta, As an individual).

Chapter 6: Supporting Soil Science and Technology

Advances in Precision Agriculture

Woodrill Ltd. agronomist Caleb Niemeyer shows senators Pat Duncan, centre, and Paula Simons how hydrochloric acid reacts to different types of soil.

During its hearings and fact-finding missions, the committee learned about the critical role of new technologies in managing and improving soil health. For farmers, precision agriculture/"smart" farming is part of the solution when it comes to protecting and preserving soil resources in Canada. Curtis Rempel, Vice-President of Crop Production and Innovation, Canola Council of Canada, told the committee: "Canadian farmers have been early adopters of innovation, including precision ag tools. This has translated into profitability, largely from improving soil health."[231] The committee also heard from several witnesses that precision farming technology is large and diverse in number.

[231] AGFO, *Evidence*, 9 March 2023 (Curtis Rempel, Vice-President of Crop Production and Innovation, Canola Council of Canada).

> *"While more work needs to be done, the adoption of precision agriculture technologies is also improving input efficiency and contributing to improved soil health over time. For example, digital technologies, extensive soil testing, satellite imagery and sectional shutoff controls ensure the right amount of nutrients are placed exactly where they are needed by the crop. Adoption of 4R Nutrient Stewardship ensures our producers are using nutrients as effectively as possible while minimizing emissions."*
>
> *Rick Burton*[232]

Jake Ayre, Vice President, Keystone Agricultural Producers of Manitoba, told the committee that his farm has become heavily involved in precision agriculture: "Variable rate, or VR, fertilization; grid soil sampling; moisture probes; electrical conductivity, or EC, mapping; and data tracking are currently some of the most important tools on our farm. As a result, we can effectively track and map seed and fertilizer placement across our farm, and correlate it with yield data after harvesting."[233]

The committee heard about the importance of precision agriculture techniques to minimize fertilizer waste and water use. For example, precision agriculture technology can perform variable rate and nitrogen application to ensure a farmer is not over spraying a field. This means less seed waste and reduces the needs for chemical fertilizer, which in turn, protects agricultural soils by minimizing compaction caused by fertilizer overuse.

On its fact-finding mission to Guelph, Ontario, the committee visited Woodrill Ltd.—a crop input supply company and grain elevator business—to learn about its soil analysis program, GroundWork. In five steps, GroundWork creates a soil map of a given field by layering topography and electrical conductivity maps, extracts deep soil cores using a hydraulic soil probe, analyzes the soil cores using soil classification systems, implements soils-based decision-making, and helps growers achieve higher returns with their crop yields. GroundWork's agronomists told the committee that it can take up to three years for farmers to adopt this program.

On its fact-finding mission to Western Canada, the committee toured Environmental Material Science Inc. (EMS) in Saskatoon, Saskatchewan. EMS is a soil science startup that develops cutting-edge technology such as soil sensors to manage, monitor and clean up soil contaminated sites

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[232] AGFO, *Evidence*, 30 March 2023 (Rick Burton, Deputy Minister of Agriculture, Government of Saskatchewan).
[233] AGFO, *Evidence*, 4 May 2023 (Jake Ayre, Vice President, Keystone Agricultural Producers of Manitoba).

throughout Canada. The committee saw how the sensors were made and how they give farmers and ranchers real-time data about moisture, salinity, and yields.

In Alberta, the committee visited Kevin Auch's farm near Carmangay and learned how he grows peas, cereals, canola, and flax across 5,000 acres using no-till and a centre-pivot irrigation sprinkler system. Auch explained how a seed drill places seeds at the correct depth and then presses soil back in the hole, limiting soil erosion and keeping vital nutrients and carbon in the soil.

The committee also visited the Olds College Smart Farm in Olds, Alberta, and learned about its research activities. Old College leads the Pan-Canadian Smart Farm Network.

Several witnesses, both in committee and on-the-ground, told the committee that long-term investments in soil science including university studies, applied research or infrastructure, are key.

How important are additional financial incentive programs in managing and improving soil health in Canada?

"Anything we can do to increase the adoption of better approaches to building soil organic matter is very important to Canadian producers," said Mary Robinson, Past President of the Canadian Federation of Agriculture.[234] "We do see some regulations that – kind of— push us away from being able to do that. I think it would be fair to say it's young farmers in particular. Here, I'm thinking of Bill C-244, the right to repair, if you're buying high-tech equipment."[235]

Bill C-244, *An Act to Amend the Copyright Act (diagnosis, maintenance and repair)*, is currently at third reading in the Senate.

Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture, agreed that farmers need the incentive to continue to adopt precision agriculture technology. "If they do not have that incentive because they are not able to repair it — when they have that small weather window to fix their machinery — then it acts as a disincentive toward the adoption of that technology and, ultimately, soil health."[236]

The committee heard that precision agriculture technology is expensive for farmers to purchase and that some of it relies on a good Wi-Fi broadband and access to connectivity, which is quite often not available in rural areas.

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[234] AGFO, *Evidence*, 16 February 2023 (Mary Robinson, Past President, Canadian Federation of Agriculture).
[235] Ibid.
[236] AGFO, *Evidence*, 16 February 2023 (Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture).

Chapter 7: International Perspectives on Soil Legislation and Policies

Introduction

From left, senators Paula Simons, Victor Oh and Rob Black participate in a panel discussion with Qu Dongyu, Director General of the Food and Agriculture Organization of the United Nations, in Rome, Italy. (Photo credit: ©FAO/Pier Paolo Cito, Giuseppe Carotenuto)

The committee learned about international perspectives on soil health, including policies and legislation, while attending the Eleventh Global Soil Plenary Partnership Assembly hosted by the Food and Agriculture Organization of the United Nations, as well as meeting with the World Farmers' Organization, in Rome, Italy.

Penny Wensley, former National Soils Advocate for the Government of Australia, urged the committee to consider the issue of legislation and whether changes are needed to provide for greater protection of soil resources in Canada:

"In my view, this is an underused tool. No one likes sticks rather than carrots, but a lot of countries are looking at this, most notably, the EU with its new EU soil health law, and the UK."[237]

European Union

Over 60% of European soils are unhealthy and scientific evidence shows that soils are further degrading due to unsustainable management of the land, sealing (the destruction or covering of soils by buildings, constructions, and layers of impermeable artificial materials such as asphalt and concrete), contamination and overexploitation, combined with the impact from climate change and extreme weather events.

The European Union (EU) is one of few jurisdictions to use legislation to provide for greater protection of soil resources. For example, under the EU biodiversity strategy for 2030, which is part of the European Green Deal, the European Commission presented a new EU soil strategy for 2030, with the aim of having all EU soil ecosystems in a healthy condition by 2050.

To achieve this objective, on July 5, 2023, the European Commission tabled a proposal for a Directive on Soil Monitoring and Resilience (Soil Monitoring Law). The Soil Monitoring Law lays down measures for monitoring and assessing soil health, based on a common definition of what constitutes healthy soil, for managing soils sustainably, and for tackling contaminated sites. The proposal aligns with the EU Zero Pollution Action Plan.

United Kingdom

Jacqueline Hannam, President, British Society of Soil Science, informed the committee that the United Kingdom is transitioning from the EU's Common Agricultural Policy to their own Environmental Land Management schemes. The schemes are currently still under development and in pilot to different nations within the United Kingdom. Hannam explained that the scheme being developed in England, for example, is linked to targets in the Environmental Improvement Plan to improve sustainable soil management by 2028 and, thus, incentivizes farmers to provide public goods for public services. Some schemes are specifically related to soils and beneficial management practices, as well as a "whole host of different things."[238]

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[237] AGFO, *Evidence*, 29 February 2024 (Penny Wensley, Former National Soils Advocate, Government of Australia, As an individual).
[238] AGFO, *Evidence*, 29 February 2024 (Jacqueline Hannam, President, British Society of Soil Science).

Australia

The Australian government's National Soil Strategy (the Strategy) is the country's first national policy on soil. It was released in May 2021 and sets out how Australia will value, manage and improve its soil for the next 20 years. The Strategy was developed in collaboration with state and territorial governments, the National Soils Advocate and other major stakeholders in soil science and land management.

The Strategy's main goals are: 1) prioritize soil health; 2) empower soil innovation and stewards; and 3) strengthen soil knowledge and capability.

Furthermore, Australia's *National Soil Action Plan 2023 to 2028* is the first of four action plans to be developed under the Strategy. It was endorsed by the Minister for Agriculture, Fisheries and Forestry on November 28, 2023 with the support of all state and territorial jurisdictions. All priority actions are linked to the three broader goals of the Strategy.

United States of America

In December 2023, the United States government announced a program, Vision for Adapted Crops and Soils (VACS), in partnership with FAO and the African Union, to invest in mapping, conserving, and building healthy soils. The United States has committed $150 million to this program so far and is asking other countries around the world to assist in this work, with the goal of mapping soils around the world, classifying them, and working to make them healthier to produce better yields and mitigate climate change.

In 2022, the United States Department of Agriculture (USDA) launched the Partnerships for Climate-Smart Commodities, a $3-billion initiative that finances partnerships to support the production and marketing of major commodities through pilot projects lasting one to five years. The initiative supports over 200 practices including soil health testing, soil residue and no-till management, carbon sequestration and GHG mitigation assessment, among others. The aim is to expand markets for the United States' climate-smart commodities, leverage the GHG benefits of climate-smart commodity production, and provide direct, meaningful benefits to production agriculture, including for small and underserved producers.

New Zealand

On soil, carbon and GHG emissions, Mel Poulton, Owner/operator of a sheep and beef farm business, and the Former Special Agricultural Trade Envoy, Government of New Zealand, told the committee that the focus of New Zealand's government and New Zealand agriculture "has been more on enteric methane emissions from ruminant livestock rather than gains in soil carbon per

se." [239] Poulton explained that in New Zealand, there is not a lot of cropping: "When we undertake pasture renewal, it's normally without tillage using direct drills. That protects the carbon we've got. We're bracing for a greenhouse gas levy on all farmers, which puts a price on enteric methane as well as nitrous oxide and carbon dioxide."[240]

[239] AGFO, *Evidence*, 6 February 2024 (Mel Poulton, Owner/operator of a sheep and beef farm business, New Zealand, As an individual).
[240] Ibid.

Chapter 8: Raising Soil's Profile

Introduction

Senator Victor Oh takes a closer look at the roots of a plant at the Canada Food and Agriculture Museum.

World Soil Day (WSD) is held annually on December 5 to highlight the importance of healthy soil and promote the sustainable management of soil resources. An international day to celebrate soil was first recommended by the International Union of Soil Sciences in 2002. Under the leadership of Thailand, and within the framework of the Global Soil Partnership, the Food and Agriculture Organization of the United Nations supported the formal establishment of WSD as a global awareness-raising platform.

Bob Turnock, Senior Science Advisor, Science and Partnerships – International, Science and Technology Branch, AAFC, affirmed that while WSD has been effective in raising an understanding of and interest in the importance of soils, it has not resulted in specific results as far as domestic legislation or action in Canada.[241] Bob Turnock is also the Canadian focal point for the Global Soil Partnership of the Food and Agriculture Organization of the United Nations.

[241] AGFO, *Evidence*, 30 November 2023 (Bob Turnock, Senior Science Advisor, Science and Partnerships – International, Science and Technology Branch, Agriculture and Agri-Food Canada).

"Although soil is moving up policy agendas, there is still insufficient understanding or appreciation of its importance and value right across government, community, industry and the private sector — certainly, low media attention," emphasized Penny Wensley, Former National Soils Advocate, Australia.[242] To better raise the profile of soil, Wensley recommended that the Government of Canada establish a National Soils Advocate position, as Australia used to have, as well as a Parliamentary Friends of Soils group, which Australia currently has.

Classrooms

Carolyn Wilson, Director, Canadian Young Farmers' Forum, believes education is crucial to changing current perceptions of farming in Canada:

> *"We need to be changing the perception of farmers in our children and youth. Some of the initiatives that Agriculture in the Classroom is doing include bringing young farmers into high schools or elementary schools — where the students are able to see that face, and think, "This could be me. It's not just my grandfather, my uncle or what have you."*
>
> *Carolyn Wilson*[243]

Agriculture in the Classroom Canada (AICC) is a national organization that creates bilingual programs and resources to support its member organizations in each of the 10 provinces who are the "boots on the ground" delivering AICC's programs and resources to elementary and high school teachers. Mathieu Rouleau, Executive Director, AICC, said the organization's mission is to "cultivate a more meaningful connection to agriculture and food for students and educators."[244] Many of its resources focus on or feature soil health. For example, agriculture flipbooks and videos are animated to show students how soil is formed. Also, the book *Alex's First Seed* shows how worms play an important role in maintaining healthy soil. AICC has a partnership with Canadian Cattle Association.

On its fact-finding mission to the Canada Agriculture and Food Museum in Ottawa, Ontario, the committee learned about the different educational programs that the museum offers to elementary and secondary schools, both in-person and virtually. Topics include: Meet Wonder

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[242] AGFO, *Evidence*, 29 February 2024 (Penny Wensley, Former National Soils Advocate, Government of Australia, As an individual).
[243] AGFO, *Evidence*, 16 February 2023 (Carolyn Wilson, Director, Canadian Young Farmers' Forum).
[244] AGFO, *Evidence*, 7 December 2023 (Mathieu Rouleau, Executive Director, Agriculture in the Classroom).

Worm, A Handful of Soil, AgVenture: Soil Science, Agriculture and the Environment, among many others.

Emmett Sawyer, Member, 4-H Canada, and a grain and cattle farmer, stated that Canada's youth are tasked with the responsibility of mitigating the effects of climate change and are looked to for solutions to this important issue.[245] 4-H Canada has contributed to this conversation, said Sawyer, by creating a hands-on outreach program called *Dig into Soil*, which is one of six outreach initiatives offered by the organization.[246] The program teaches youth how healthy soils contribute to addressing climate change, empowers them to be champions of soil conservation within their own communities, and shows them why soil can contribute to achieving some of the UN's Sustainable Development Goals.[247]

Regarding educational barriers, Melissa Arcand, Soil Biogeochemist, University of Saskatchewan, told the committee: "Indigenous peoples have historically been left out of soil science and agricultural education. First Nations students are under-represented in the soil science and agricultural fields at the undergraduate and graduate levels across Canada, and thus Indigenous professionals in these fields are incredibly rare." [248]

Other witnesses told the committee that there has been a disinvestment in soil science throughout Canada and insisted that more education about soil is needed.

[245] AGFO, *Evidence*, 7 December 2023 (Emmett Sawyer, Member, 4-H Canada).
[246] Ibid.
[247] Ibid.
[248] AGFO, *Evidence*, 9 February 2023 (Melissa Arcand, Soil Biogeochemist, University of Saskatchewan, As an Individual).

Consumers

Senators Paula Simons and Rob Black take a closer look at a pile of vermicompost at the Canada Food and Agriculture Museum, in Ottawa, Ontario.

Farm and Food Care Ontario, a registered charity that aims to provide credible information on food and farming in Canada, is primarily funded by farmers, farm organizations and agri-businesses. The organization works closely with its sister groups in Saskatchewan and PEI on a variety of national projects focused on connecting consumers with their food. Kelly Daynard, Executive Director, Farm and Food Care Ontario, revealed that in working with consumers, soil — and its critical importance to everyone — is never top of mind to non-farming Canadians.[249]

[249] AGFO, *Evidence*, 7 December 2023 (Kelly Daynard, Executive Director, Farm & Food Care Ontario).

> *On a bus tour a few years ago, a farmer was speaking to my guests about the challenges related to his farm's soil type. One guest on the bus raised her hand to ask, "If farmers don't like their soil type, why don't they just change it?" And that led to a fascinating conversation about soil types, soil health and the challenges farmers face when growing crops in a variety of soil conditions.*
>
> *Kelly Daynard*[250]

The committee heard that organizations such as Farm and Food Care Ontario and Saskatchewan, AICC and 4-H Canada "spend a lot of time with our hands out in the agricultural community, looking for funding to do our amazing projects."[251] Daynard explained that Farm and Food Care's flagship project, *The Real Dirt on Farming*, is an expensive booklet to produce. The organization is also collaborating with Agriculture in the Classroom Canada on an educator guide, and with 4-H Canada on a 4-H resource to go with the guide.

"I'm proud that I work with farmers' dollars, but we could use more. Certainly, talking about soil health is really critical, and the audiences that the three of our groups reach need to know that information. We could use help," said Daynard.[252]

[250] Ibid.
[251] Ibid.
[252] Ibid.

For Clinton Monchuk, Executive Director, Farm and Food Care Saskatchewan, one of the biggest challenges is consumer disconnect on modern technologies in agriculture, including the use of genetically modified crops or spraying herbicides that have been vetted through and approved by Health Canada and the Canadian Food Inspection Agency:

> *When we talk to consumer groups, dieticians, doctors and people in health and wellness, we explain that what we're doing through these new technologies is a huge positive, and they're amazed. They didn't know. I think that is one of the biggest hurdles, and that's what we're trying to overcome.*
>
> *Clinton Monchuk*[253]

Rebecca Lee, Executive Director, Fruit and Vegetable Growers of Canada, cautioned: "We're losing farmland not only because of development but also because of a lack of ability or interest in that [farmland]. That's something else that needs to be considered. There's an urgency there."[254]

Some of the easiest ways to better engage consumers in soil health are "u-pick" programs that help people get their hands dirty,[255] and visiting farms to get to know farmers and their operations better.[256]

The committee heard that consumer disconnect also extends to the circular economy. Colby Hansen, Owner/Operator, Hansen Beef, stated: "One challenge, I suppose, is the garbage that is in the compost. It's polluted with garbage, and there is a huge gap in educating the public. There's also a huge opportunity to reconnect the urban and rural people. One of our goals in doing these soil studies and compost trials is to show the benefits."[257] Hansen continued, "[…] For example, if we say, "Hey, if you divert your food waste in a responsible manner, I will grow you a pound of beef that is more nutrient dense." It connects people back to the soil, and from there, I feel everyone will be incentivized to do a better job of sorting their organics."[258]

Consumer misperceptions also extend to soil health and organic farming in Canada. Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University: "Organic farming is leading the charge, really, in looking at ways of linking to urban sources of phosphorus and closing that loop because

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[253] AGFO, *Evidence*, 7 December 2023 (Clinton Monchuk, Executive Director, Farm & Food Care Saskatchewan)
[254] AGFO, *Evidence*, 9 March 2023 (Rebecca Lee, Executive Director, Fruit and Vegetable Growers of Canada).
[255] AGFO, *Evidence*, 7 December 2023 (Hugh Maynard, Interim Chief Executive Officer 4-H Canada).
[256] AGFO, *Evidence*, 7 December 2023 (Kelly Daynard, Executive Director, Farm & Food Care Ontario).
[257] AGFO, *Evidence*, 14 December 2023 (Colby Hansen, Owner/Operator, Hansen Beef).
[258] Ibid.

organics cannot rely, at the moment, on phosphorus fertilizer. So, there's an incentive in organic systems to look at closing those urban-rural nutrient flows."[259]

Antonius Petro, Executive Director, Regeneration Canada, insisted: "The government must ensure that our fellow consumers realize the critical role that soil plays in public health, economic development, food, adaptation, and climate change mitigation. This would be achieved with the support of organizations like Regeneration Canada and ALUS, which work tirelessly to bring together and connect producers and consumers on a national scale."[260] The committee also heard that, in 2022, the Canadian Cattle Association provided input on a proposed project to develop a Canadian soil health network that looks at the overall benefits of soil health for both farmers and consumers:

> *"Proven societal benefits include cleaner water, enhanced biodiversity and reduced threats from flooding, and, more specifically, farmers benefit from increasing productivity, greater resilience in the face of a changing climate, reduced environmental liability and better overall profitability, while consumers gain in terms of greater food security, fewer environmental concerns and healthier, more nutrient-dense food."*
>
> *Duane Thompson*[261]

[259] AGFO, *Evidence*, 14 December 2023 (Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University, As an individual).
[260] AGFO, *Evidence*, 27 October 2022 (Antonius Petro, Executive Director, Regeneration Canada).
[261] AGFO, *Evidence*, 23 November 2023 (Duane Thompson, Environment Committee Co-Chair, Canadian Cattle Association).

Conclusion

After 2 years of digging deep, the committee learned that soil is at risk and that soil degradation occurs in every region of Canada. The committee also heard about and saw firsthand the valuable work that Canadian farmers, ranchers, and growers are doing—supported by agronomists, academia, industry, and the provinces and territories—to improve soil health and be sustainability leaders. We believe that Canadian agriculture and agricultural soils offer solutions for mitigating the effects of climate change and addressing food security in this country.

> *"Testimony during the past 18 months effectively brought into focus every element of soil health as it contributes to human health, environmental health, urban soil management, forest productivity, water and air quality and our capacity to produce food. The interaction among these elements has been shown to be real and to be important. We live in a holistic environment."*
>
> *Don Lobb*[262]

In line with AAFC's *What We Heard Report: Sustainable Agriculture Strategy,* the soil study witnesses urged the Government of Canada to:

- acknowledge regional differences related to climates, soil types, and beneficial management practices;
- apply an economic and social lens for policies and programs;
- better recognize and compensate the early adopters for their sustainable practices;
- encourage scientific and technical innovation; and,
- enhance soil data collection, soil data management, and soil knowledge transfer throughout the country.[263]

Enhancing, protecting, and preserving agricultural soil now and for the future must be a priority of the Government of Canada and all Canadians and it must be built into land use planning policies. At our final hearing, Don Lobb, farmer, and life-long soil advocate, reminded the committee—and all Canadians—that "The most important thing that would be of value to this report is to have ethics embedded in it based on the use of foodland soil as a privilege that comes with responsibilities."[264]

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[262] AGFO, *Evidence*, 29 February 2024 (Don Lobb, Farmer, As an individual).
[263] Government of Canada, "1. Executive Summary," *What We Heard Report: Sustainable Agriculture Strategy*.
[264] AGFO, *Evidence*, 29 February 2024 (Don Lobb, Farmer, As an individual).

With its work in the preparation of this report, your Senate committee has tried to fulfill its responsibilities, and we hope that the recommendations we make will enable others to do the same.

APPENDIX A – Witnesses

Thursday, September 22, 2022

Don Lobb, Farmer, As an individual

Cedric MacLeod, Executive Director, Canadian Forage and Grassland Association

Tuesday, September 27, 2022

Laura L. Van Eerd, Professor, Sustainable Soil Management, University of Guelph, As an individual

David Lobb, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba, As an individual

Nadir Erbilgin, Professor and Chair, Department of Renewable Resources, University of Alberta, As an individual

Angela Bedard-Haughn, Professor and Dean, College of Agriculture and Bioresources, University of Saskatchewan, As an individual

Thursday, September 29, 2022

Joann K. Whalen, James McGill Professor of Soil Science, McGill University, As an individual

Marie-Élise Samson, Agronomist and Assistant Professor in Soil Science, Laval University, As an individual

Christopher Burn, Chancellor's Professor of Geography, Carleton University, As an individual

Sean Smukler, Associate Professor, Applied Biology and Soil Science, University of British Columbia, As an individual

Tuesday, October 4, 2022

Kier Miller, Chair, Soil Conservation Council of Canada

Tim Nerbas, Past Chair, Soil Conservation Council of Canada

Susan Antler, Executive Director, Compost Council of Canada

Glenn Munroe, Manager, Special Projects, Compost Council of Canada

Paul Thoroughgood, National Manager, Sustainable Agriculture, Ducks Unlimited Canada

Thursday, October 6, 2022

Jason Lenz, Chair, Canadian Roundtable for Sustainable Crops

Susie Miler, Executive Director, Canadian Roundtable for Sustainable Crops

Asim Biswas, Chair, Canadian Society of Soil Science

Amanda Diochon, President-Elect, Canadian Society of Soil Science

Thursday, October 20, 2022

David Burton, Distinguished Research Professor, Faculty of Agriculture, Dalhousie University, As an individual

Brandon Heung, Associate Professor, Faculty of Agriculture, Dalhousie University, As an individual

Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University, As an individual

Tuesday, October 25, 2022

Cindy Prescott, Professor, Department of Forest and Conservation Sciences, University of British Columbia, As an individual

Sean Thomas, Research Professor, University of Toronto, As an individual

Al Mussell, Director, Research, Canadian Agri-Food Policy Institute

Marc-André Viau, Director, Government Relations, Équiterre

Carole-Anne Lapierre, Analyst, Agriculture and Food Systems, Équiterre

Thursday, October 27, 2022

Bryan Gilvesy, Chief Executive Officer, ALUS

Antonious Petro, Executive Director, Regeneration Canada

Thursday, November 3, 2022

Andrea Brocklebank, Executive Director, Beef Cattle Research Council

Reynold Bergen, Science Director, Beef Cattle Research Council

Pierre Petelle, President and Chief Executive Officer, CropLife Canada

Ian Affleck, Vice President, Biotechnology, CropLife Canada

Cassandra Cotton, Vice President, Policy and Programs, Fertilizer Canada

Thursday, February 9, 2023

Melissa Arcand, Soil Biogeochemist, University of Saskatchewan, As an individual

Candice Pete-Cardoso, Director, Indigenous Land Management Institute, University of Saskatchewan, As an individual

Kenneth Bear, First Nation Professional Agrologist, Agriculture Development Manager, Pasqua First Nation Group of Companies

Jacob Beaton, Owner, Tea Creek Training and Employment

Tuesday, February 14, 2023

Gilles Saindon, Assistant Deputy Minister, Science and Technology Branch, Agriculture and Agri-Food Canada

Marco Valicenti, Director General, Innovation Programs Directorate, Agriculture and Agri-Food Canada

Edward G. Gregorich, Research Scientist, Science and Technology Branch, Agriculture and Agri-Food Canada

Heather McNairn, Research Scientist, Science and Technology Branch, Agriculture and Agri-Food Canada

Dominic St-Pierre, Director General, Laurentian Forestry Centre, Natural Resources Canada

Thursday, February 16, 2023

Mary Robinson, Past President, Canadian Federation of Agriculture

Brodie Berrigan, Director of Government Relations and Farm Policy, Canadian Federation of Agriculture

Carolyn Wilson, Director, Canadian Young Farmers' Forum

Martin Caron, President and Chief Executive Officer, Union des producteurs agricoles

Daniel Bernier, Agricultural Research and Policy Advisor – Environment, Union des producteurs agricoles

Thursday, March 9, 2023

Erin Gowriluk, Executive Director, Grain Growers of Canada

Jocelyn Velestuk, Farmer, Grain Growers of Canada

Rebecca Lee, Executive Director, Fruit and Vegetable Growers of Canada

Kristjan Hebert, President, Hebert Group

Curtis Rempel, Vice-President of Crop Production and Innovation, Canola Council of Canada

Denis Tremorin, Director, Sustainability, Pulse Canada

Thursday, March 23, 2023

Randy Lamb, Agrologist, Department of Energy, Mines and Resources, Government of Yukon

Brandon Drost, Forester, Department of Energy, Mines and Resources, Government of Yukon

Kumari Karunaratne, President, Canadian Permafrost Association

Michelle Blade, Permafrost Scientist, Nunavut, Canadian Permafrost Association

Janet Dean, Executive Director, Territorial Agrifood Association

Thursday, March 30, 2023

Rick Burton, Deputy Minister of Agriculture, Government of Saskatchewan

Mark Raymond, Executive Director, Extension and Support Services Branch, British Columbia Ministry of Agriculture and Food, Government of British Columbia

Dieter Geesing, Provincial Soil Specialists, British Columbia Ministry of Agriculture and Food, Government of British Columbia

Christine Brown, Field Crops Sustainability Specialist, Agriculture Development Branch, Ontario Ministry of Agriculture, Food and Rural Affairs, Government of Ontario

Daniel Saurette, Land Resource Specialist, Soil, Environmental Management Branch, Ontario Ministry of Agriculture, Food and Rural Affairs, Government of Ontario

Thursday, April 20, 2023

Trevor Wallace, Provincial Nutrient Management Specialist, Natural Resource Management Branch, Alberta Agriculture and Irrigation, Government of Alberta

Patti Rothenburger, Assistant Deputy Minister, Manitoba Agriculture, Government of Manitoba

Marla Riekman, Land Management Specialist – Soils, Manitoba Agriculture, Government of Manitoba

Thursday, May 4, 2023

Ian Boxall, President, Agricultural Producers Association of Saskatchewan

Jake Ayre, Vice President, Keystone Agricultural Producers of Manitoba

Paul Pryce, Director of Policy, BC Agriculture Council

David Rourke, Farmer, As an individual

Thursday, May 11, 2023

Donald Killorn, Executive Director, Prince Edward Island Federation of Agriculture

Thursday, May 18, 2023

Jason Mann, Chief Executive Officer, CarbonTerra

Rachel Hor, Chief Operating Officer, Carbon Terra

Marty Seymour, Chief Executive Officer, Carbon RX Inc.

William Greuel, Chief Executive Officer, Protein Industries Canada

Nate Kelly, Chief Executive Officer, Miraterra

Kim Haakstad, Vice President, Stakeholder Relations, Miraterra

Thursday, June 1, 2023

Angela Straathof, Program Director, Ontario Soil and Crop Improvement Association (OSCIA)

Tori Waugh, Executive Director, Ontario Soil Network

Thursday, June 8, 2023

Benoit Legault, Director General, Producteurs de grains du Québec

Catherine Lefebvre, President, Association des producteurs maraîchers du Québec

Catherine Lessard, Deputy General Manager, Association des producteurs maraîchers du Québec

Thursday, June 15, 2023

Jerry V. DeMarco, Commissioner of the Environment and Sustainable Development, Office of the Auditor General of Canada

Marie-Pierre Grondin, Director, Office of the Auditor General of Canada

Nathan Basiliko, Professor of Forest Soils, Faculty of Natural Resources Management, Lakehead University, As an individual

Mohamad Yaghi, Agriculture & Climate Policy Lead, Climate Action Institute, Royal Bank of Canada

Lara O'Donnell, Executive Director, Weston Family Foundation

Thursday, November 2, 2023

E.P. (Ted) Taylor, soil Resource Specialist, Soil Resource Group

Paul Renaud, Chief Executive Officer, The Lanigan Group

Kevin Boon, General Manager, BC Cattlemen's Association

Paul Arp, Professor, Forest Soils, Forestry and Environmental Management, University of New Brunswick, As an individual

Ken Van Rees, Professor Emeritus, Forest Soils, University of Saskatchewan, As an individual

Thursday, November 9, 2023

Megan Sipos, Manager, Research and Policy, Greenbelt Foundation

Paul Smith, Consultant, Research and Policy, Greenbelt Foundation

Cheyenne Sundance, Farmer, Sundance Commons

Justine Hendricks, President and Chief Executive Officer, Farm Credit Canada

Todd Klink, Executive Vice-President and Chief Marketing Officer, Farm Credit Canada

Stuart Chutter, Senior Policy Analyst, Agriculture Financial Services Corporation

Dean Orr, Farmer, As an individual

Thursday, November 23, 2023

Catherine Stewart, Ambassador for Climate Change, Environment and Climate Change Canada

Vincent Ngan, Assistant Deputy Minister, Climate Change Branch, Environment and Climate Change Canada

Judy Meltzer, Director General, Carbon Market Bureau, Environmental Protection Branch, Environment and Climate Change Canada

Kelly Torck, Acting Director General, Biodiversity Policy and Partnerships, Environment and Climate Change Canada

Lindsay Pratt, Director, Pollutant Inventories and Reporting, Science and Technology Branch, Environment and Climate Change Canada

Jackie Mercer, Program Manager, Offsets & Emissions Trading, Environment and Climate Change Canada

David MacMillan, President and Chief Executive Officer, Deveron

Robin Woodward, Director, Carbon Asset Solutions

Simon Lafontaine, Co-Founder, Écoboeuf

William Newton, Governor, Western Stock Growers' Association

Duane Thompson, Environment Committee Co-Chair, Canadian Cattle Association

Reynold Bergen, Science Director, Beef Cattle Research Council, Canadian Cattle Association

Don McCabe, Chair, Biological Carbon Canada

Graham Gilchrist, Chief Executive Officer, Biological Carbon Canada

Thursday, November 30, 2023

Stephen Balsom, Assistant Deputy Minister, Agriculture and Lands, Department of Fisheries, Forestry and Agriculture, Government of Newfoundland and Labrador

Mike Gravel, Director, Forest Management, Northwest Territories Environment and Climate Change, Government of the Northwest Territories

Carla Millar, Manager, Sustainable Agriculture, Department of Agriculture, Government of Prince Edward Island

David Lobb, Vice Chair, Intergovernmental Technical Panel on Soils, Food and Agriculture Organization of the United Nations

Bob Turnock, Senior Science Advisor, Science Partnerships – International, Science and Technology Branch, Agriculture and Agri-Food Canada

Pascal Michel, Director General, Ontario – Quebec Region, Science and Technology Branch, Agriculture and Agri-Food Canada

Thursday, December 7, 2023

Mathieu Rouleau, Executive Director, Agriculture in the Classroom

Hugh Maynard, Interim Chief Executive Officer, 4-H Canada

Emmett Sawyer, Member, 4-H Canada

Kelly Daynard, Executive Director, Farm & Food Care Ontario

Clinton Monchuk, Executive Director, Farm & Food Care, Saskatchewan

Steven D. Siciliano, Professor, Department of Soil Science, University of Saskatchewan, As an individual

Derek MacKenzie, Associate Professor, Department of Renewable Resources, University of Alberta, As an individual

Thursday, December 14, 2023

Jo-Anne St. Godard, Executive Director, Circular Innovation Council

Colby Hansen, Owner/Operator, Hansen Beef

Asha Hingorani, President, Canadian Sphagnum Peat Moss Association

Tia Loftsgard, Executive Director, Canada Organic Trade Association

Roger Chevraux, Chair, Canadian Canola Growers Association

Dave Carey, Vice President, Government and Industry Relations, Canadian Canola Growers Association

Greg Donald, General Manager, Prince Edward Island Potato Board

Ryan Barrett, Research and Agronomy Specialist, Prince Edward Island Potato Board

Derek Lynch, Professor, Faculty of Agriculture, Dalhousie University, As an individual

Tuesday, February 6, 2024

Hugh Harley, Professor of Practice, Global Economy, University of Sydney, As an individual

Ravi Naidu, Chief Executive Officer and Managing Director, crcCARE

Mel Poulton, Owner/operator of a sheep and been farm business, New Zealand, As an individual

Alec Mackay, Principal Scientist, Digital Agriculture, AgResearch

Tuesday, February 13, 2024

Alan White, Vice President and Climate Change Adaption Chair, Canadian Nursery and Landscape Association

Phil Paxton, Past-President, Canadian Ornamental Horticulture Alliance

Cristine Morgan, Chief Scientific Officer, Soil Health Institute

Melanie Bos, Agriculture Policy Manager, Nature Conservancy of Canada

David Hiltz, Director, Global Regulatory Affairs, Acadian Plant Health

Thursday, February 15, 2024

Daniel Alessi, Professor and Encana Chair in Water Resources, Department of Earth and Atmospheric Science, University of Alberta, As an individual

Gordon Price, Professor, Department of Engineering, Faculty of Agriculture, Dalhousie University, As an individual

Subhasis Ghoshal, Professor, Civil Engineering and Director, Trottier Institute for Sustainability in Engineering and Design, McGill University

Francis Zvomuya, Professor, Department of Soil Science, Faculty of Agricultural and Food Sciences, University of Manitoba

Thursday, February 29, 2024

Stuart Oke, Co-Owner of Rooted Oak Farm, National Farmers Union

Robert Andjelic, Chief Executive Officer, Andjelic Land Inc.

Katherine Aske, Farmer, Researcher, University of British Columbia, As an individual

Don Lobb, Farmer, As an individual

Penny Wensley, former National Soils Advocate, Government of Australia, As an individual

Jacqueline Hannam, President, British Society of Soil Science

APPENDIX B – Fact-Finding Missions

July 31 to August 5, 2022 | Glasgow, Scotland

World Congress of Soil Science 2022

Penny Wensley, National Soils Advocate, Government of Australia

December 1, 2022 | Ottawa, Ontario

Canada Agriculture and Food Museum

Christina Tessier, Ingenium Chief Executive Officer

Kerry-Leigh Burchell, Director General

Nadine Dagenais-Dessaint, Manager, Education and Exhibition Interpretation

April 24 to April 26, 2023 | Guelph, Ontario

University of Guelph

Nancy Brown Andison, Chair, Board of Governors

Malcolm Campbell, Professor, Vice-President Research

Kari Dunfield, Professor, Soil Microbiologist

Richard Heck, Professor, School of Environmental Sciences

Paul Sibley, Professor, Director of the School of Environmental Sciences

Laura L. Van Eerd, Professor, Sustainable Soil Management

Claudia Wagner-Riddle, Professor Agrometeorologist

Heather White, Knowledge Mobilization and Communications Coordinator, Soils at Guelph

Agri-Businesses and Private Sector Companies

Mike Buttenham, Manager, Sustainability, Syngenta Canada

Greg Hannam, Owner, Woodrill Ltd.

Brett Israel, Co-Owner, Farmer, 3Gen Organics

Carl Israel, Co-Owner, Farmer, 3Gen Organics

Jamie Israel, Co-Owner, Farmer, 3Gen Organics

Nathan Klages, Biologicals Business Manager, Syngenta Canada

Tara McCaughey, Head, Technology Solutions and Sustainable Ag, Syngenta Canada

Nevin McDougall, President, Side Road 13 Investments Inc.

Caleb Niemeyer, Agronomist and Precision Ag Specialist, Woodrill Ltd.

Fernando Olea, Head, Marketing, Syngenta Canada

Ravi Ramachandran, Head, Research and Development for Crop Protection, Syngenta Canada

Lynn Schmidt, Lead Council, Syngenta Canada

Anna Shulkin, Head, Regulatory and Stewardship, Syngenta Canada

Christine Stroud, Head, Corporate Affairs, Syngenta Canada

E.P. (Ted) Taylor, Soil Resource Specialist, Soil Resource Group

Matt Wallenstein, Chief Soil Scientist, Syngenta Canada

Soil Associations

Harry Stoddart, Executive Director, Ontario Soil and Crop Improvement Association

Woody Van Arkel, Chair, Board of Directors, Ontario Soil Network; Farmer

As Individuals

Dan Breen, Farmer

Don Lobb, Farmer

Lillie Ann Morris, Farmer

July 10 to July 18, 2023 | Rome, Italy

Food and Agriculture Organization (FAO) of the United Nations (UN)

Qu Dongyu, Director General

Beth Bechdol, Deputy Director General

Alex Jones, Director, Resources Mobilization and Private Sector Partnership Division

Lifeng Li, Director, Land Water Division

Lauren Phillips, Deputy Director, Inclusive Rural Transformation and Gender Equality Division

Maria Helena Semedo, Deputy Director General

Máximo Torero Cullen, Chief Economist

Ronald Vargas, Secretary, Global Soil Partnership

Marcela Villareal, Director, Partnerships and UN Collaboration Division

Zhimin Wu, Director, Forestry Division

Jingyuan Xia, Director, Plant Production and Protection

Kaveh Zahedi, Director, Climate Change, Biodiversity and Environment Division

Agricultural Producer Organizations

Francesco Brusaporco, Policy Officer, Advocacy, Policy and Partnerships, World Farmers' Organisation

Cristina Chirico, Head of International Office, Italian Farmers' Confederation, CIA Agricoltori italiani

Valeria Di Marzo, Practice Leader, Communications, World Farmers' Organisation

Albina Gerxhaliu, Executive Assistant, World Farmers' Organisation

Arianna Giuliodori, Secretary General, World Farmers' Organisation

Peter Haussman, Markets and Controls, Fondazione Campagna Amica

Ambra Raggi, Engagement Manager, World Farmers' Organisation

Industry Associations

Paola De Santis, Soil Scientist, Consultative Group on International Agricultural Research

Michael Haywood, Consultative Group on International Agricultural Research

Manoj Kaushal, Soil Scientist, Consultative Group on International Agricultural Research

Job Kihara, Soil Scientist, Consultative Group on International Agricultural Research

Javier Mateo-Vega, Global Director of Partnerships and Communications, Consultative Group on International Agricultural Research

Agri-Businesses and Private Sector Companies

Claudio Destro, CEO, Maccarese Farm

Hilary Lanzi, Livestock Sector, Maccarese Farm

August 27 to September 1, 2023 | Saskatoon, SK and Calgary, Carmangay, Olds, AB

Olds College of Agriculture and Technology

Joy Agnew, Vice President, Research

Ben Curtis, President

Todd Ormann, Vice President, Development

University of Calgary

Renate Weller, Dean, Veterinary Medicine

University of Saskatchewan

Melissa Arcand, Soil Biogeochemist Associate Professor, Department of Soil Science

Angela Bedard-Haughn, Professor and Dean, College of Agriculture and Bioresources

Kate Congreves, Associate Professor, Department of Plant Sciences

Bobbi Helgasson, Soil Microbial Ecologist, Assistant Professor

Candice Pete-Cardoso, Director, Indigenous Land Management Institute

Baljit Singh, Vice-President Research

Jeff Schoneau, Professor and Ministry of Agriculture Strategic Research Program Chair in Soil Nutrient Management

Agricultural Producer Organizations

Kevin Auch, Chair, Alberta Pulse Growers; Farmer

Ian Boxall, Agricultural Producers Association of Saskatchewan; Farmer

Fred Lozeman, Finance Chair, Board of Directors, Alberta Beef Producers; Rancher

Mark Lyseng, Lead, Government and Policy, Alberta Beef Producers; Rancher

Lindsye Murfin, Head, Western Stock Growers' Association, Grasslands Capital X

Bill Newton, Western Stock Growers' Association, Grasslands Capital X; Rancher, South Porcupine Ranching Ltd.

Norm Ward, Western Stock Growers' Association, Grasslands Capital X

Environmental and Soil Associations

Kimberly Cornish, Director, Food Water Wellness Foundation

Kristine Nichols, Lead Soil Scientist, Food Water Wellness Foundation

Industry Associations

Jeff English, Vice-President, Marketing and Communications, Pulse Canada

Jeff Nielson, Past President, Grain Growers of Canada; Farmer

Denis Tremorin, Director, Sustainability, Pulse Canada

Agri-Businesses and Private Sector Companies

Frank Hart, Board Chair, Protein Industries Canada

Justine Hendricks, President and CEO, Farm Credit Canada

Todd Klink, Executive Vice-President, Farm Credit Canada

Jason McNamee, Chief Operations Officer and Senior Biogeoscientist, Lucent Biosciences

Rob O'Connor, Farm Show Director, Ag in Motion

Steven Siciliano, Professor, Department of Soil Science, University of Saskatchewan; CEO, Environmental Material Sciences Inc.

Blake Weiseth, Director of Research and Demonstration, Glacier FarmMedia Discovery Farm

As Individuals

Doug Wray, Wray Ranch; Rancher

APPENDIX C – List of Briefs

A complete list of the briefs and follow-up information received during the study can be found at: https://sencanada.ca/en/committees/AGFO/briefs/44-1.

- Follow-up information provided by Agriculture and Agri-Food Canada
- Briefs from Agriculture Carbon Alliance
- Brief from Doug Aspinall, Woodrill Farms, As an individual
- Follow-up information from Jacob Beaton, Owner, Tea Creek Training and Employment
- Follow-up information from Michelle Blade, Permafrost Scientist, Canadian Permafrost Association
- Follow-up information from Melanie Bos, Agriculture Policy Manager, Nature Conservancy of Canada
- Brief from Chuck Broughton, General Manager, Canada, Pivot Bio
- Brief from the Canadian Council of Academies
- Follow-up information from Dave Carey, Vice President, Canadian Canola Growers Association
- Follow-up information from Roger Chevraux, Chair, Canadian Canola Growers Association
- Brief from Cassandra Cotton, Vice President, Policy and Program, Fertilizer Canada
- Follow-up information from Jerry V. DeMarco, Commissioner of the Environment and Sustainable Development, Office of the Auditor General of Canada
- Fact Sheet from Équiterre
- Report from Équiterre
- Follow-up information from Basia Florio, Executive Advisor to the Deputy Minister, Government of Ontario
- Brief from Graham Gilchrist, Chief Executive Officer, Biological Carbon Canada
- Follow-up from Justine Hendricks, President and Chief Executive Officer, Farm Credit Canada
- Brief from J.L. (Les) Henry, Professor Emeritus Soil Science, University of Saskatchewan, As an individual
- Brief from Brandon Heung, Associate Professor, Dalhousie University, As an individual
- Brief from Asha Hingorani, President, Canadian Sphagnum Peat Moss Association
- Brief from Blain Hjertaas, Regenerative Farmer, Hjertaas Farms in Saskatchewan

- Briefs from Rachel Hor, Chief Operating Officer, CarbonTerra
- Follow-up information from Rachel Hor, Chief Operating Officer, CarbonTerra
- Brief from Pari Johnston, Vice President, Genome Canada
- Brief from Gord Kurbis, Senior Associate, T. Bjornson and Associates Consulting Inc.
- Follow-up information from Rebecca Lee, Executive Director, Fruit and Vegetable Growers of Canada
- Follow-up information from Benoit Legault, Director General, Producteurs de grains du Québec
- Brief from David Lobb, Vice Chair, Food and Agriculture Organization of the United Nations
- Supplementary information from Don Lobb, Farmer, As an individual
- Follow-up information from Don Lobb, Farmer, As an individual
- Follow-up information from Donald Lobb, Farmer, As an individual
- Follow-up information from Tia Loftsgard, Executive Director, Canada Organic Trade Association
- Brief from Derek MacKenzie, Associate Professor, University of Alberta, As an individual
- Letter from Don McCabe, Chair, Biological Carbon Canada
- Brief from Don McCabe, Chair, Biological Carbon Canada
- Brief from Clinton Monchuk, Executive Director, Farm & Food Care Saskatchewan
- Brief from Medha Muhunthan, A Voice to Save Soil from Canada, As an individual
- Brief from Rick Munroe, National Farmers Union
- Brief from New Brunswick Department of Agriculture, Aquaculture and Fisheries
- Follow-up information from Lara O'Donnell, Executive Director, Weston Family Foundation
- Brief from Ontario Soil and Crop Improvement Association
- Briefs from Dean Orr, Farmer, As an individual
- Brief from Keith Reid, As an individual
- Brief from Karen Ross, Director, Farmers for Climate Solutions
- Brief from David Rourke, Farmer, As an individual
- Follow-up information from Troy Sherman, Director, Canola Council of Canada
- Follow-up information from Steven D. Siciliano, Professor, University of Saskatchewan
- Supplementary Information from the Soil Conservation Council of Canada
- Brief from Raju Soolanayakanahally, Research Scientist, Agriculture and Agri-Food Canada

- Follow-up from Christina Stroud, Head, Syngenta Canada
- Follow-up from Paul Thoroughgood, National Manager, Ducks Unlimited Canada
- Follow-up from Jim Tokarchuk, Executive Director, Soil Conservation Council of Canada
- Brief from the University of Guelph
- Brief from George Wamala, Director, RBC Climate Action Institute
- Correspondence from Penelope Wensley, Former National Soils Advocate for Australia, National Soil Strategy of Australia, As an individual
- Brief from Canada Organic Growers

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