CEREALS CANADA

Environmental Sustainability of Canadian Oats

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Executive Summary

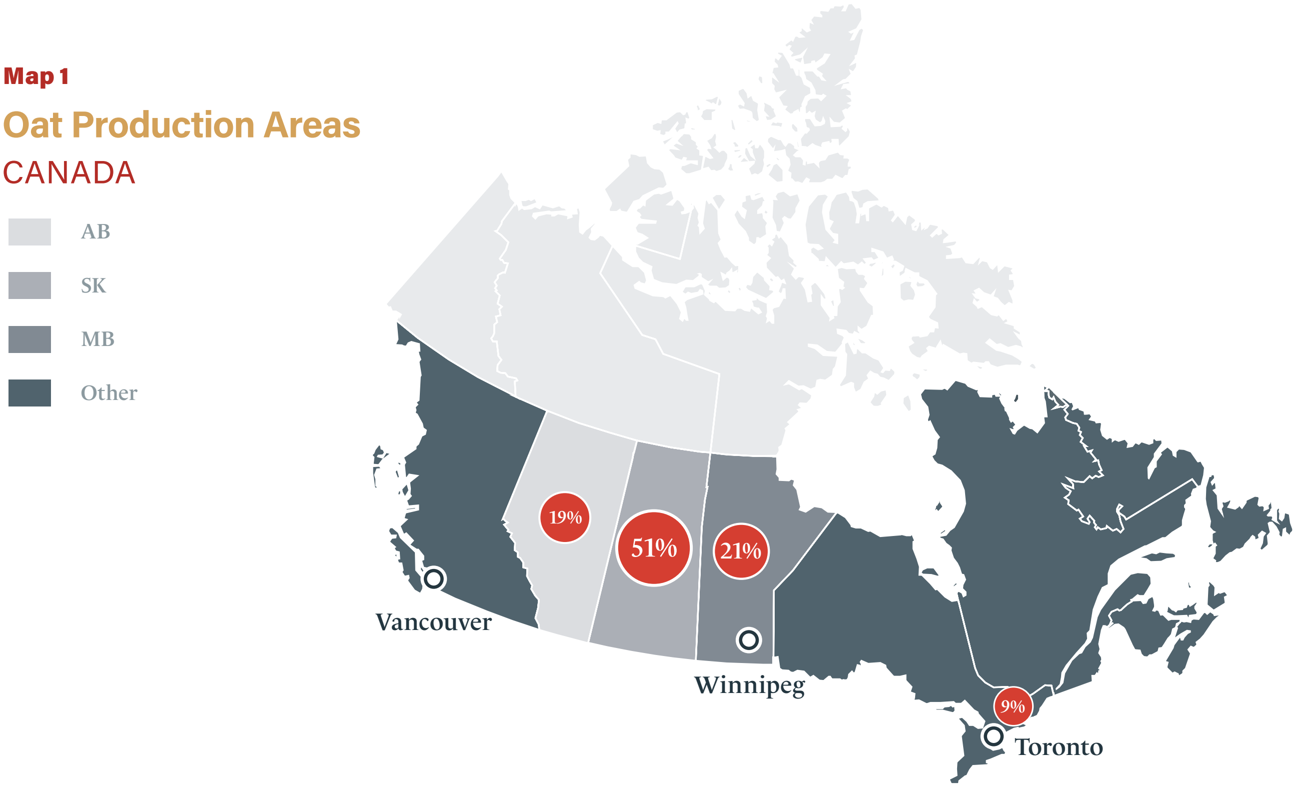
In Canada, oats are seeded to over 3.3 million acres with a 5-year average production of over 3.7 million tonnes annually (Statistics Canada, 2025b). Canada is a major supplier of oats, making up the majority of world oat exports. Canadian oats supply three primary markets: milling oats for human consumption, performance or pony oats as feed for high-end race or competitive horses, and high-yielding feed oat varieties. Over the last five years, the United States has been Canada's largest oat importer, accounting for 81% of Canada's oat exports (Cereals Canada, 2025a).

Agricultural production of adequate quantities of high-quality food will be one of the most important challenges for humanity in the next century. The concept of sustainability is one of the forefront concepts in discussions of the challenges facing agriculture, given the pressing need to increase food production in a sustainable way. In this situation of growing awareness, increasing emphasis on environmentally sustainable production of agricultural products has led to a demand for measurements of environmental sustainability.

Map 1

Oat Production Areas

CANADA



This report was prepared by Cereals Canada to respond to these demands, with the purpose of evaluating the environmental sustainability of the production of oats, a key Canadian agriculture commodity.

In this report, Cereals Canada compares the sustainability of Canadian oat production systems to two other major oat production systems, Australia and Sweden, using six sustainability indicators: (1) carbon footprint of oat production, (2) soil organic carbon (SOC) sequestration, (3) fertilizer use and efficiency, (4) irrigation water use, (5) pesticide use, and (6) soil erosion.

The indicators were developed using quantitative measurements using robust, sound data to evaluate the environmental sustainability of Canadian oat production. For each indicator, oat-specific data was used when possible, however, when data availability precluded this, Cereals Canada has indicated when cropland-specific data was used.

Based on our analysis, the following conclusions can be made about the sustainability of Canadian oat production:

1. The carbon footprint of oats per tonne of grain in Canada is lower than that of oats grown in Sweden and comparable to the carbon footprint of oats produced in Australia when soil organic carbon (SOC) sequestration is not accounted for. When SOC sequestration is factored in, the carbon footprint of Canadian oats is substantially reduced.
2. Canadian cropland soil is a carbon dioxide (CO_2) sink, with a 5-year average CO_2 sequestration of 14.2 million tonnes per year
3. Application rates of fertilizer for Canadian oat production reflect efficient management of fertilizer that optimizes yields and mitigates fertilizer losses. Canadian croplands have a high sustainable nitrogen management index, a measurement that accounts for responsible nutrient management and crop yield potential.
4. In Canada, oat production is an efficient user of water resources. Irrigation pressures are minimal as the majority of oat is grown under dryland conditions. This is consistent with oat production in Australia and Sweden.
5. Pesticides are strictly regulated in Canada to ensure their safety for human health and the environment. Pesticides are a tool used for oat production in Canada, Australia, and Sweden. Glyphosate is an herbicide approved for use in all three countries and is subject to comparable label application rates for analogous products.
6. Conservation management practices adopted by Canadian oat producers such as conservation or no-till management and diversification of crop rotations facilitate soil carbon sequestration, maintain or improve soil health, and mitigate soil erosion, such that soil erosion in Canada has declined substantially and over 80% of cropland in Canada is classified as "very low risk" (soil erosion rates less than 2.5 tonnes per acre per year).

Canadian farmers have responded to demands for sustainable food production by adopting new technologies and conservation management practices that have reduced the environmental impact of Canadian oat production. Investment by the Canadian government and the private sector into research, innovation, and incentivization are necessary to build upon the environmental sustainability gains already achieved by oat producers and the Canadian agricultural sector as a whole.

Assessing the Sustainability of Canadian Oats

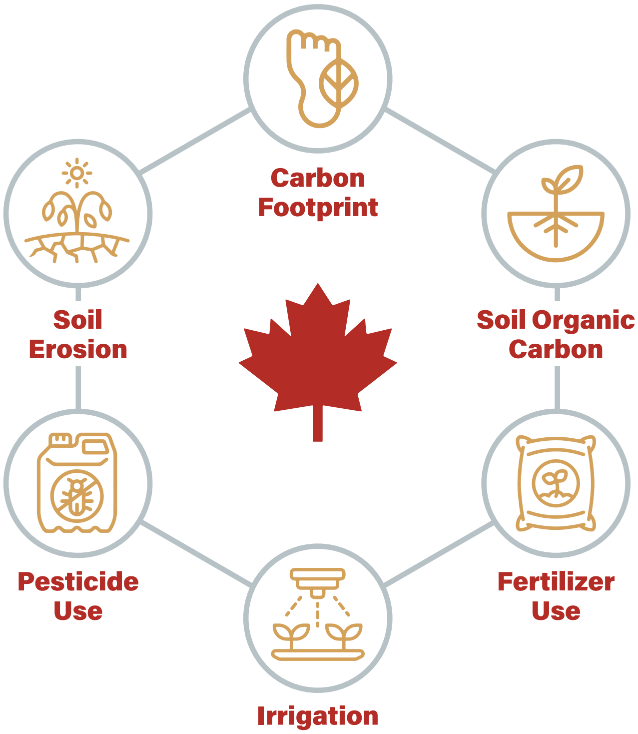
The benefits from agriculture are immense; agriculture provides quality food, fuel, and fibre. Continuing to meet the demand for agricultural products will be an important challenge for humanity in the next century (Lampridi et al., 2019). Global demand for major grains is expected to increase 70%, due to greater pressure from a global population expected to reach 9.7 billion by 2050 (Gan et al., 2014; Tilman et al., 2011; Beres et al., 2020). Sustainable agricultural intensification is necessary to maintain global food security and nutritional needs (Lampridi et al., 2019; Ajibade et al., 2023). Increasing emphasis on sustainable production of agricultural products has led to a demand for measurements of environmental sustainability. Environmental sustainability for agriculture means managing our natural resources to meet society's food, fuel, fibre, and feed needs without compromising the ability of future generations to meet their needs (Lampridi et al., 2019).

Oats are a small but important grain cereal and forage crop. In Canada, oats are seeded to over 3.3 million acres with a 5-year average production of over 3.7 million tonnes annually (Statistics Canada, 2025b). Canada is a major supplier of oats, making up the majority of world oat exports.

Canadian oats supply three primary markets:

- milling oats for human consumption,
- performance or pony oats as feed for high-end race or competitive horses, and
- high-yielding feed oat varieties.

Figure 1 Six indicators to evaluate the sustainability of Canadian barley production relative to production of oats in Australia and Sweden.



Over the last five years, the United States has been Canada's largest oat importer, accounting for 81% of Canada's oat exports (Cereals Canada, 2025a).

To evaluate the environmental sustainability of Canadian oat production, Cereals Canada has developed a set of six environmental sustainability indicators: carbon footprint, soil organic carbon sequestration, fertilizer use and efficiency, irrigation water use, pesticide use, and soil erosion (Figure 1).

The indicators were developed to evaluate the environmental sustainability of Canadian oat production and relate to environmental challenges that stakeholders in the agriculture sector seek to address (Latruffe et al., 2016). The selected indicators rely on data that are scientifically sound, defensible, and robust, recognizing that their development is subject to data availability. For each indicator, oat-specific data were used when possible, however, when data availability precluded this, Cereals Canada have indicated when general cropland level data were used.

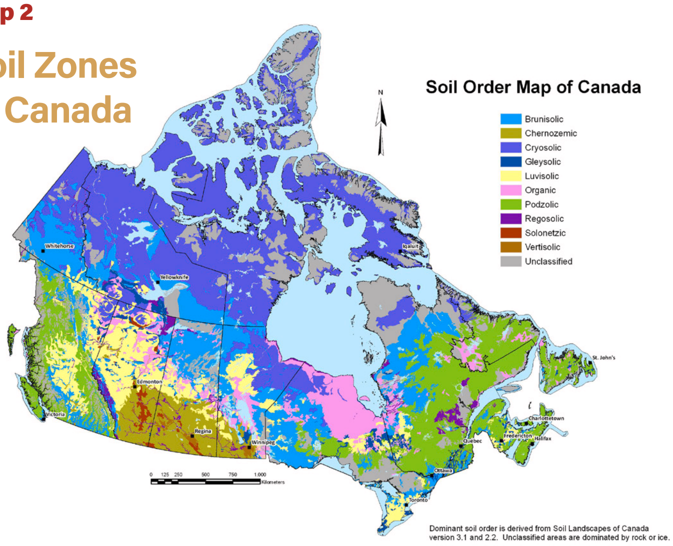
The selected indicators were then applied to two other major oat producing regions, Australia and Sweden, to comparatively evaluate the sustainability of Canadian oat production. The direct comparison of environmental indicators between nations is challenging because of regional differences in production practices, environmental conditions, economic activity, and the availability of data across countries, therefore these indicators do not act as direct comparisons but instead should be used as a guide to understand the sustainability strengths of Canadian oat production in a broader context.

Oats are primarily grown in the Western Canadian provinces of Alberta, Saskatchewan, and Manitoba, with small areas of production in British Columbia and Eastern Canada. In general, the oat growing region is characterized by its aridity (McGinn, 2010).

There are five soil zones (Brown, Dark-brown, Black, Grey and Dark grey) with a general precipitation gradient along these soil types; the Brown soil zone is the most arid and the Black/Grey zones are wetter and cooler, resulting in higher soil organic matter (Awada et al. 2021).

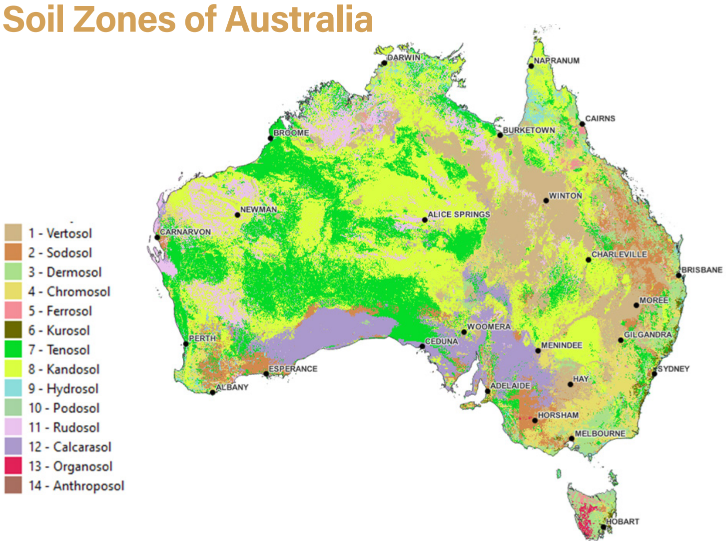
Map 2

Soil Zones of Canada



Map 3

Soil Zones of Australia

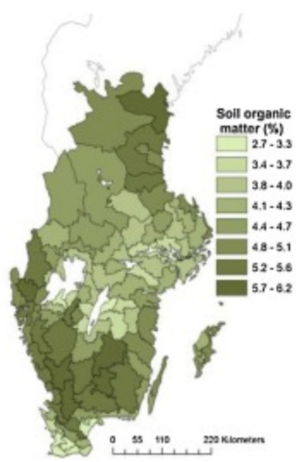


In Australia, oats are grown in Western Australia, Victoria, and New South Wales and therefore a wide range of soil types. Soils in the grain production areas of the eastern and southeastern states range from highly fertile, clay-rich soils to coarse textured slightly acidic soils, and low fertility sandy soils dominate the agricultural zones of the southwest (Soil Quality, 2024).

Oat production in Sweden is concentrated in the southern part of the country, however, the range of production extends more north than other grains. Sandy to silty loam soils are dominant with moderate fertility with approximately 4% organic matter and neutral pH (Kirchmann et al., 2020). Oats in Sweden are grown in a nordic climate with a short growing season.

Map 4

Soil Zones of Sweden



The Carbon Footprint of Canadian Oats and Soil Organic Carbon Sequestration

Terminology:

Carbon footprint is the sum of greenhouse gas (GHG) emissions caused directly and indirectly by the production of a product, reported as kg of carbon dioxide equivalents (CO_2eq) per tonne of grain production (kg CO_2eq per tonne).

The CO_2eq is used to compare the emissions from three major greenhouse gases (carbon dioxide [CO_2], nitrous oxide [N_2O], and methane [CH_4]) on the basis of their global-warming potential by converting N_2O and CH_4 to the equivalent amount of CO_2 (Pandey and Agrawal, 2014). Importantly, carbon footprint estimates can vary substantially depending on the individual methodologies, therefore, only comparable carbon footprint calculations are considered in the estimates. The system boundaries of the carbon footprints included upstream emissions including those from the production of all of crop inputs (e.g., fertilizer, pesticide, and seed) and on-farm emissions and removals associated with oat production to the storage bin.

Soil organic carbon (SOC) sequestration is the process by which CO_2, a major contributor to CO_2eq, is removed from the atmosphere and stored in soil as SOC. This process is mediated by plants via photosynthesis but can be augmented or diminished by agricultural management practices.

Agricultural management practices that promote the formation and persistence of SOC, such as conservation or no-till, cover cropping, and reduction of summer fallow, offset emissions of CO_2.

Life cycle analyses that focus on quantifying the environmental impacts of oat production are limited. The carbon footprint of oat production is reported as the export weighted average range of the European Union (EU), as Sweden-specific publications were not available. Heusala et al. (2020) conducted a life cycle assessment of the major oat exporters of the EU. When oat cultivation input-output data was not available for a country, countries were assumed to be representative of other countries with a similar yield, e.g. cultivation in Finland was considered representative of cultivation in Sweden. Finland and Sweden are the largest European oat exporters, thus the weighted average carbon footprint of EU oat production is used as a proxy for the carbon footprint of oat production in Sweden.

Conversely, agricultural practices that result in SOC decomposition and release as CO_2 can increase the carbon footprint of a crop. About 9% of Swedish agricultural soils are classified as organic soils, which are emission 'hotspots' and considered to be major sources of CO_2 and N_2O (Berglund et al., 2021). Thus, the carbon footprint of oat production in the EU may be elevated relative to Canada and Australia as emissions from peat land cultivation were included in the carbon footprint calculation by Heusala et al. (2020).

In addition to offsetting CO_2eq emissions, agricultural practices that promote SOC sequestration also promote soil fertility (Feller et al., 2012), reduced erosion (Borrelli et al., 2016), improved soil water holding capacity (Lal, 2020), and mitigation of pesticide risk (Perez-Lucas et al., 2021). Thus, continued adoption of practices that maximize SOC by Canadian farmers is a cornerstone of Canadian agricultural sustainability and has resulted in Canadian cropland soil being an annual sink of 14.2 million tonnes of CO_2 (5-year average) (ECCC, 2024). Thus, the carbon footprint of oat production in Canada is substantially reduced when accounting for SOC sequestration (Table 1).

Table 1 Range of carbon footprints for oat production per tonne of grain for Canada, Australia, and the EU with and without accounting for soil organic carbon (SOC) sequestration

Product	Net Emissions (kg CO_2e per tonne)
Canadian Oats	300-349 (CRSC 2021; Viana et al., 2022; Field to Market Canada, 2023)
Canadian Oats (with SOC)	100-265 (CRSC, 2021; Desjardins et al., 2020; Field to Market Canada, 2023)
Australian Oats	219-248 (Carbon Neutral Grain Project, n.d.; Eady et al., 2012)
Australian Oats (with SOC)	n.d.
EU	500 – 770 (Koraseth et al., 2012; Uusitalo et al., 2019; Rajaniemi et al., 2011
EU (with SOC)	330 – 580 (Heusala et al., 2019)

Based on an extensive national network of long-term field experiments and a long history of applied and fundamental research, Canada has developed a deep understanding of the nature and dynamics of SOC in its agricultural soils, their spatial distribution, and how SOC responds to management practices (Minasny et al., 2017). Long-term experiments have studied SOC changes over decades, resulting in reliable quantitative SOC information for agricultural soils in Canada (Table 2) (He et al., 2021).

Table 2 Emissions of carbon dioxide (CO_2) from soil organic carbon (SOC) changes associated with cropland management in Canada, Australia, and Sweden

Region	Rate of SOC change[L] (Mg CO_2 per ac per yr)
Canada	0.13 (ECCC, 2024)
Australia	0.01 (Australian Government, 2024)
Sweden	-0.19 (Swedish Environmental Protection Agency, 2023)

[L] *Negative values denote losses of SOC (i.e., source of CO2), positive values indicate SOC sequestration (i.e., sink of CO2)*

One such experiment is the Prairie Soil Carbon Balance Project (PSCB), which was initiated by the Saskatchewan Soil Conservation Association in 1997 to monitor SOC in agricultural soils across Saskatchewan that were converted from conventional tillage to no-till with continuous cropping. The findings of the PSCB conclusively show that SOC is increasing in the agricultural soils in Saskatchewan, the province with 75% adoption of no-till practices, more than 90% conservation tillage adoption, and produces 46% of Canadian Oats (He et al., 2021; McConkey et al., 2020 Statistics Canada, 2025b).

In comparison, Australian agricultural soils are neutral or a small CO_2 sink under business-as-usual management, and the extent to which SOC storage can be increased in Australian agricultural soils by adoption of improved management practices is poorly understood (Bamber et al., 2023; Luo et al., 2019; Robertson and Nash, 2013) (Table 2).

Mineral soils in Sweden act as a CO_2 sink, however, cultivation of organic soils for arable crops, including oats, have resulted in Swedish cropland being a net source of CO_2 (Table 2). Recently, national trends of increased conversion from annual to perennial crops in Sweden have contributed to increased SOC sequestration in mineral soils, but full transition of cropland soils from a source to a sink may require efforts to reduce organic soil drainage and restoration of the original hydrologic conditions of peatlands (Johansson et al., 2023).

Of note, accounting for SOC change in carbon footprint calculations is increasingly complicated, because rates of SOC change are gradual; affected by current management practices and by the amount of total SOC, the latter being a legacy of past land use management. Importantly, SOC sequestration is reliant on continued adoption and maintenance of regionally suitable practices that facilitate the formation and persistence of SOC, and if the C sequestration practice is ceased, SOC can be lost from soils at a rate faster than the C accrued. Additionally, the soil saturation concept suggests that rates of SOC accumulation slow over time, reaching a quasi-equilibrium state. Thus, when comparing different agricultural production systems, saturation effects may require consideration, as failure to do so may result in an overestimation of SOC sequestration potential (Nazir et al., 2024). However, the concept of SOC saturation is still debated in literature, and conflicting results suggest this is an area that requires more research to fully understand the continued SOC sequestration potential of Canadian croplands in the future (Awada et al., 2021).

Fertilizer Use and Nutrient Use Efficiency

Increasing agricultural productivity remains the most viable pathway for attaining the great challenge of feeding 9.8 billion people by 2050, of which a food production increase of at least 70% is required (Alexandratos and Bruinsma, 2012; Dimkpa et al., 2020). Plants require nutrients such as nitrogen (N), phosphorus (P), and potassium (K) for optimal growth and productivity. Without fertilizer, intensive agricultural production would result in soil nutrient mining and long-term soil nutrient depletion, thus fertilizer application maintains soil fertility by replenishing nutrients removed during harvest (Tenorio et al., 2020). Simultaneously, fertilizer production results in the release of greenhouse gases (GHGs) and the over application of fertilizer can lead to environmental consequences (Gao and Serrenho, 2023). Therefore, carefully balancing crop nutrient requirements for global food security with soil fertility and environmental considerations is a significant challenge faced by Canadian farmers. Table 3 presents typical nutrient application rates for oat production in Canada, Australia, and Sweden.

Table 3 Average application rates of nitrogen (N), phosphorus (P) and potassium (K) for oat production in Canada, Australia, and Sweden from Ludemann et al. (2022).

Region and crop	N application (lb N per ac)	P application (lb P per ac)	K application (lb K per ac)
Canada	62-65	22-26	5
Australia	30	23	3
Sweden	67	18	13

Application rates of N, P, and K for oat production are generally comparable for Canada and Sweden, but higher than for Australia, which is consistent with differences in production practices. Australian cropping systems are generally fertilized at lower rates due to limited moisture that constrains yields (Global Yield Gap Atlas, n.d.).

Terminology:

Nutrient balance is calculated as the difference between nutrient inputs and outputs and is therefore an indicator of excess or insufficient use of nutrients from fertilizers and other sources in crop production (Ludemann et al., 2023; OECD, 2023).

Nutrient deficit (negative value) indicates declining soil fertility.

Nutrient surplus (positive value) indicates an excess of nutrient.

Fertilizer application rates alone cannot fully assess the sustainability of agroecosystem fertilizer use. Nutrient balance is calculated as the difference between the nutrient inputs entering an agroecosystem and the nutrient outputs leaving the system (i.e., via harvest). The greater the nutrient surplus, the greater the risk of adverse effects to soil, water, and air.

Nutrient balances can be a useful metric by quantifying nutrient flows and representing the resource use efficiency of agricultural systems (Ludemann et al., 2023). Comparable data on soil nutrient budgets is a useful tool to assess and monitor agricultural performance between countries, such as the country-specific nutrient balances for N and P summarized in Table 4.

Table 4 5 year average nutrient balances of nitrogen (N) and phosphorus (P) for agricultural land in Canada, Australia, and Sweden from OECD (2023).

Region	N balance (lb N per ac)	P balance (lb P per ac)
Canada	24	1
Australia	17	1
Sweden	34	0

An additional method to evaluate sustainable nutrient use in agroecosystems is through indicators such as the Sustainable Nitrogen Management Index (SNMI) (Table 5).

Table 5 The Sustainable Nitrogen Management Index (SNMI) for croplands in Canada, Australia, and Sweden from EPI (2022).

Region	SNMI
Canada	67.3
Australia	42.9
Sweden	63.6

To represent the need to balance both food production and environmental protection, Zhang et al. (2022b) developed the unitless SNMI, which is a metric that combines the performance in crop yield and N use efficiency to evaluate country-specific sustainable N management. A score of 100 indicates that a country is optimizing both crop yields and fertilizer application, and a score of 0 indicates a country has among the worst performance on the SNMI (EPI, 2022).

Irrigation Use

Irrigation has multiple benefits, including increasing crop yields and yield stability and permitting the diversification of crop rotation, which is considered a best management practice to increase SOC stocks and promote soil biodiversity (Zhang et al., 2021). Simultaneously, globally increasing water demands from the agricultural sector are confounded by threats of overexploitation and inefficient management of water resources, which threatens the resource base upon which agriculture is dependent (De Fraiture and Wichelns, 2010). This underscores the importance of efficient consumption of irrigation water, and the need for sustainable water management by the agricultural sector.

In Canada, only a small portion of cropland is irrigated, with less than 2% of the total area receiving irrigation (Statistics Canada, 2023). Irrigated oat acres contribute very little to this, as the majority (approximately 90%) of oats are grown in the Canadian prairie provinces where it is rarely economically efficient to irrigate oats (Ziesman et al., 2010). Overall, irrigation water withdrawals in Canada are negligible in the context of water availability (Table 6) (Bhatti et a., 2021).

Table 6 Irrigation water usage for oat production in Canada, Australia, and Sweden.

Region	Irrigation water usage (thousand megalitres per yr) [L]
Canada	41-60 (Statistics Canada, 2023, 2024)
Australia	32-60 (Australian Bureau of Statistics, 2022, 2023)
Sweden	~4 (Eurostat, 2012; OECD, 2019; Statistics Sweden, 2022)

[L] *These values are calculations based on available data.*

Irrigation is a useful tool for agricultural producers in Australia, the most arid inhabited continent in the world. Despite this, currently less than 10% of total arable land is equipped for irrigation (Australian Government, 2021; Muleke et al., 2022). Critically, while irrigation contributes to a more resilient crop production sector, Australia is prone to severe water scarcity and therefore strong consideration must be paid to the trade-offs between human needs and conservation of natural capital (Borsato et al., 2020). Similar to Canada, the majority of oat production is rainfed and thus irrigation water withdrawals are minimal (Ridoutt and Poulton, 2009).

In Sweden, the vast majority of agricultural production is rainfed, and there is a lack of data on irrigation. Depending on sources and years, only 1.7% to 3.8% of Swedish arable land is irrigated (Grusson et al., 2021). While existing irrigation withdrawals are limited, future changes in rainfall patterns as a result of global climate change may have implications for food production and agricultural practices in Sweden. According to Grusson et al. (2021), adaptation of Swedish agriculture to include irrigated agriculture should considered, as projected future irrigation needs in Sweden will increase, particularly for cereal crops.

Pesticide Use

Pesticides play an important role in modern agriculture and global food security, as they allow farmers to grow more food on the same land base by reducing weed, disease, and insect pressure and competition for resources, thus preventing increased conversion of land into agricultural land and protection of native ecosystems (Vicini et al., 2021). The ability to increase crop yield and improve crop production practices relies on pesticides. Pesticides help to decrease the need for other weed control methods like tillage, keeps carbon in the soil and reduces the use of farm equipment, therefore reducing fossil fuel use (Duke, 2020; Krimsky, 2021; Damalas and Eleftherohorinos, 2011).

Pesticides include a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, and nematicides, which have a longstanding and particularly important role in agriculture by protecting crops and improving productivity (Aktar et al., 2009).

Pesticides are strictly regulated in Canada to ensure their safety for human health and the environment. Indeed, Canada has one of the most stringent regulatory systems in the world for pesticides. Effective management of pesticide use mitigates pesticide risk while providing farmers with the tools they require to provide society with reliable access to safe and nutritious food.

Globally, the most widely used chemical herbicide worldwide is N-(phosphonomethyl) glycine, commonly referred to as glyphosate (Kolakowski et al., 2020). Glyphosate, the active ingredient in Roundup® brand herbicides, works by inhibiting an enzymatic process in plants, bacteria, and fungi that is absent in mammals and birds (Vicini et al., 2021). The availability of glyphosate facilitates the adoption of minimum or no-tillage cropping, enabling greater yields and yield stability, particularly for arid and semi-arid ecosystems (Beckie et al., 2020). In 2019, the Swedish Agricultural Board commissioned a report that concluded that banning glyphosate would increase tillage, reduce cover crop adoption, and increase greenhouse gas emissions as a result of increased fuel consumption and the need for a larger production area due to yield decreases (Jordbruks verkt, 2019).

In Canada, glyphosate is subject to rigorous science-based assessments by Health Canada scientists before being approved for use and must be re-evaluated on a regular basis to ensure it does not present risks of concern to human health or the environment when used according to label directions. The most recent re-evaluation was conducted in 2017, followed by a statement in 2019 wherein Health Canada reiterated that the scientific basis for the 2017 re-evaluation decision for glyphosate was sound.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is responsible for assessing the safety of glyphosate products, and most recently considered evidence for a formal reconsideration of glyphosate in 2017, which concluded after a rigorous risk-based assessment that there is no scientific basis to revise the existing registrations for glyphosate-containing products (APVMA, 2017).

As of December 2023, the European Union, which sets the framework for the regulations regarding pesticides in its member countries, renewed the approval of glyphosate for 10 more years after a rigorous assessment that did not identify any critical concerns.

Glyphosate use in Canada, Australia, and Sweden is subject to comparable label application rates for analogous products, reflecting similar usage guidelines between the three countries (Table 7).

Table 7 Label use rates for comparable glyphosate-containing products in Canada, Australia, and Sweden.

Region	Roundup Brand Product(s)	Application rate (lb acid equivalent per ac)
Canada	Roundup Transorb Roundup Weathermax	0.24 – 3.84 (Bayer, 2020a; Bayer, 2020b)
Australia	Roundup Roundup Ultra MAX	0.16 – 2.85 (Sinochem Australia, 2015; Bayer Australia, n.d.)
Sweden	Roundup PowerMax	0.89 – 2.25 (Kemi, 2023)

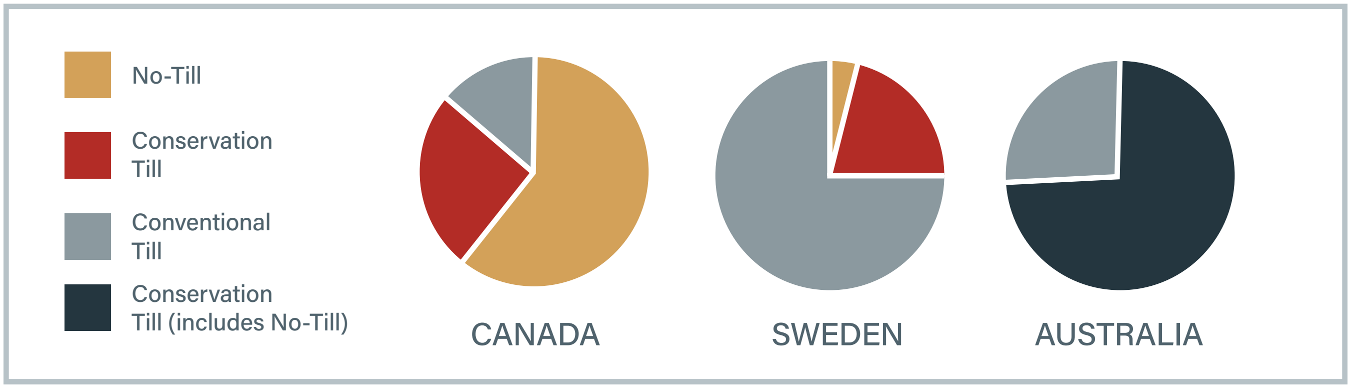
Soil Erosion

Conservation management practices on agricultural lands include, but are not limited to, conservation or no-till management, diversification of crop rotations, cover cropping, and the establishment of vegetative buffer strips and grassed waterways (Stang et al., 2016). These practices, or combinations thereof, can be applied to maintain or improve soil health depending on their regional and production system suitability, as optimum soil management practices differ from one soil to another (Norris et al., 2022).

While 90% of Canadian oats are primarily grown in the prairie provinces of Alberta, Manitoba, and Saskatchewan, Eastern Canada produces over 300,000 tonnes of oats per year under different climate, soil, and production systems. Therefore, conservation management practices for oat production have been implemented in areas across Canada that best suit their adoption. (Statistics Canada, 2025b)

Over the past 25 years, producers on the Canadian prairies have transitioned away from using tillage as the dominant form of weed control, which has resulted in soil moving from being a net emitter of carbon to sequestering carbon as SOC (Sutherland et al., 2021). Over two-thirds of the Canadian prairie provinces are under conservation tillage practices. Approximately 75% of Saskatchewan cropland is under no-till management, positioning oat production systems in Canada as a global leader in no-till adoption. Saskatchewan represents 46% of total Canadian oat production. (Figure 2) (Canadian Grain Commission, 2022; Congreves et al., 2015; Statistics Canada, 2022a, 2022b, 2025b).

Figure 2 Proportion of cropland under different tillage regimes in Canada, Sweden, and Australia (Statistics Canada, 2022b; Llewellyn and Ouzman, 2020; Eurostat, 2024).



In combination with crop rotation, minimum or no-till practices adopted by producers in Canada have maintained or enhanced soil health (Awada et al., 2021). Crop rotation is practiced by more than 95% of producers (Statistics Canada, 2024). Minimizing tillage and rotating crops is proven to improve soil biological, physical, and chemical properties for plant development, including but not limited to increasing levels of soil organic matter, total nitrogen, soil biological activity, and soil physical quality parameters such as water infiltration rate (Congreves et al., 2015). No-till adoption statistics are similar for Australia: according to the Australian government, approximately 68% of farms minimize tillage (ABERES, 2024; Llewllyn and Ouzman, 2020).

Comparatively, a large proportion of tillage practices in Sweden are unreported. However, for the share that is reported, conventional tillage constitutes approximately 70% of tillage on arable lands (Eurostat, 2024).

A key element of sustainable agriculture is conservation soil management, which requires minimizing and mitigating soil erosion (Poesen, 2018; Sartori et al., 2019). Soil erosion is recognized as a major environmental problem causing a loss of topsoil and nutrients, reduced soil fertility and consequently reduced crop yields (Telles et al., 2011; Zhao et al., 2013). Soil erosion can also increase SOC turnover and therefore increase emissions of CO_2, exacerbating global warming (Lugato et al., 2018).

Overall, soil erosion in Canada has declined in recent years, most drastically in the prairie provinces of Alberta and Saskatchewan, which experienced an increase in the share of cropland under the very low erosion risk class from 49% in 1981 to 86% in 2006 (Table 8) (Lobb et al., 2016).

Table 8 Soil erosion rates based on measured and modelled data for Canada, Australia, and Sweden.

Region	Erosion rate
Canada	Average cropland erosion rates of 0.3 t per ac per yr, with 80% of Canada's cropland erosion risk classified as very low (< 2.5 t per ac per yr). (Badreldin and Lobb, 2023; Li et al., 2010; McConkey et al., 2010; Zarrinabadi, 2023).
Australia	Cropland erosion rates of 0.5 – 2.7 t per ac per year (Cropland erosion rates of 0.5 – 2.7 t per ac per year (Government of Western Australia, 2013; Tan et al., 2021; Zhang, 2022a).
Sweden	Cropland erosion rates ranging from 0.01 to > 2.5 t per ac per year. Approximately 97% of agricultural land has low erosion rates <0.01 t per ac per year (Zhou et al., 2021; Eurostat, 2020).

This is largely due to the adoption of conservation management practices by Canadian producers that minimize erosion risk, such as no-till and reduced summer fallow (Awada et al., 2021; Fox et al., 2012; McConkey et al., 2010).

Australian agricultural soils are vulnerable to degradation processes including erosion, which is occurring at unsustainable rates and has a critical impact on agricultural productivity (Bui et al., 2011; Pereira et al., 2023). An inherently variable climate, combined with sparse vegetation cover over about much of the continent, and the typically poorly structured, shallow, and infertile topsoil make the Australian continent particularly susceptible to erosion, namely in the zones of intensive land use. Erosion rates have been reduced over time due to implementation of best management practices, but continued improvement in groundcover management is needed to minimise erosion risk under a drying climate (OECD, 2015).

In general, the erosion rates of agricultural land in Sweden are low and improving, likely due to the implementation of region-specific best management practices (Zhou et al., 2021). However, soil erosion from agricultural land remains the main cause of soil loss and eutrophication due to phosphorus translocation in Sweden. Recent large-scale topographic data indicate that high relative erosion risk areas are situated in the central and west part of the country, with soil loss rates reaching 0.8 to 2 tonnes per acre per year on arable lands (Barreiro and Martensson, 2022).

Conclusions

Sustainability is one of the defining concepts of agriculture today. It is both a major challenge as well as an opportunity for Canada to be a global leader in the provision of high quality, nutritious, and environmentally sustainable products, including oats.

Canadian farmers have responded to demands for sustainable food production, as evidenced by the widespread adoption of regionally specific conservation management practices across Canada, which has resulted in Canadian soils becoming a substantial net carbon sink. Because of this, the carbon footprint of oat production in Canada is very low. Additionally, Canadian oat growers manage nutrient applications to maximize food production and minimize losses, efficiently utilize water resources to grow their crops, and adopt conservation management practices that have minimized soil erosion and protected soil health.

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