CEREALS CANADA

Environmental Sustainability of Canadian Barley

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Contents

List of Figures

List of Maps

List of Tables

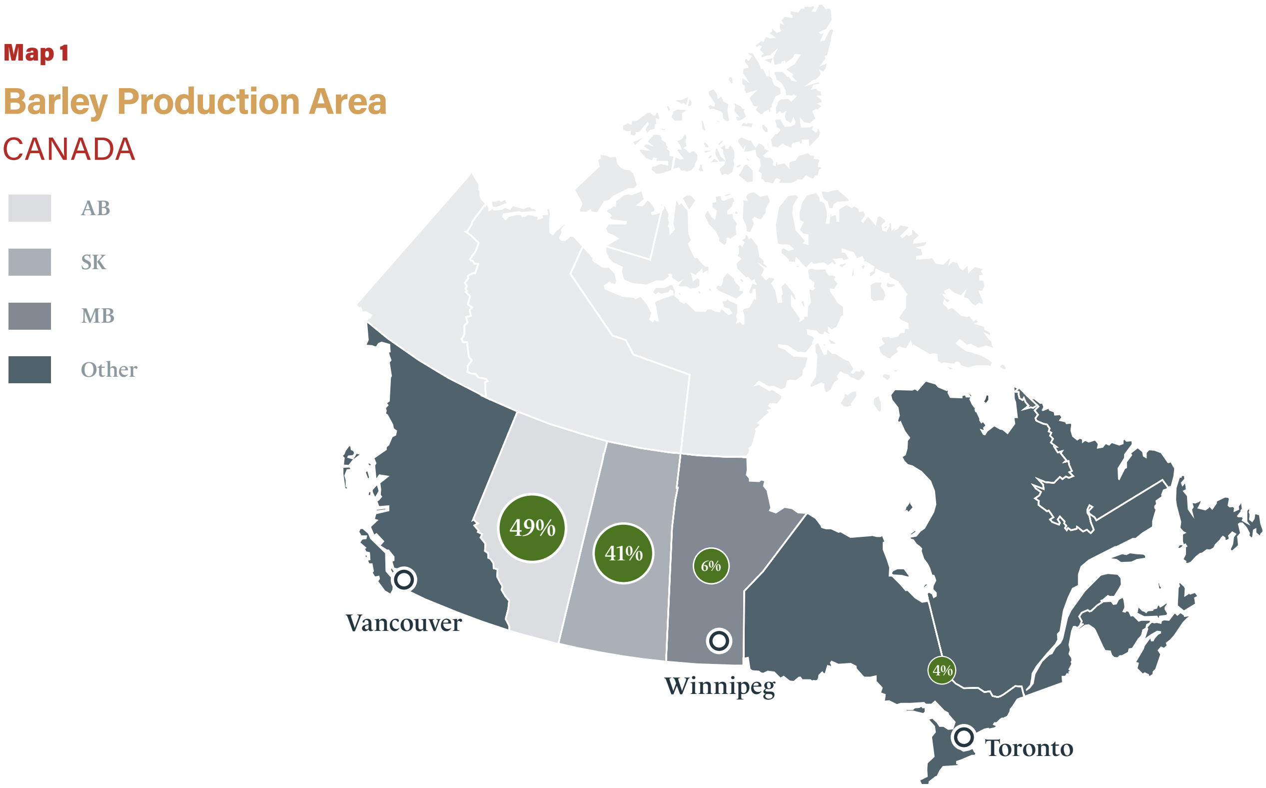
Executive Summary

Barley is an ancient cereal grain that has been grown and consumed for thousands of years. In North America, barley is a major crop used for animal feed as well as for malt for brewing. Critically, barley is a stress tolerant crop that has substantial potential to address sustainability challenges (Newton et al., 2011). Canadian barley is seeded to over 7.3 million acres, with a 5-year average annual production of almost 9 million tonnes (Statistics Canada, 2025). In the 2023-24 crop year, Canada exported 2.3 million tonnes of barley, making it the fourth largest exporter of malt barley (International Grains Council, 2025).

Map 1

Barley Production Area

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 a key Canadian agricultural commodity, barley.

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.

In this report, Cereals Canada compares the sustainability of Canadian barley production systems to two other major barley production systems, Australia and France, using six sustainability indicators: (1) carbon footprint of barley 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 data to evaluate the environmental sustainability of Canadian barley production. For each indicator, barley-specific data was used when possible, however, when data availability precluded this, Cereals Canada have indicated when cropland-specific data was used.

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

1. The carbon footprint of barley per tonne of grain in Canada is comparable to the carbon footprint of barley produced in Australia or France when soil organic carbon (SOC) sequestration is not accounted for. When SOC sequestration is accounted for, the carbon footprint of Canadian barley is substantially reduced.
2. Canadian cropland soil is a carbon dioxide (CO_2) sink, with a 5-year average SOC sequestration rate of 14.2 million tonnes of CO_2 per year.
3. Application rates of fertilizer for Canadian barley production reflect efficient management of fertilizer that optimizes yields and mitigates fertilizer losses. Canadian fertilizer application rates and barley yields are greater than Australia, but reduced compared to France, where nitrogen fertilizer rates are approximately 45% higher.
4. In Canada, barley production efficiently utilizes water resources. Irrigation pressures are minimal as the vast majority of barley is grown under dryland conditions. This is consistent with Australia and French production systems.
5. Pesticides are strictly regulated in Canada to ensure their safety for human health and the environment. Pesticides are a tool used for barley production in Canada, Australia, and France. 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 barley producers such as conservation tillage or no-till and diversification of crop rotations facilitate SOC 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).

Overall, 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 barley 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 barley producers and the Canadian agricultural sector as a whole.

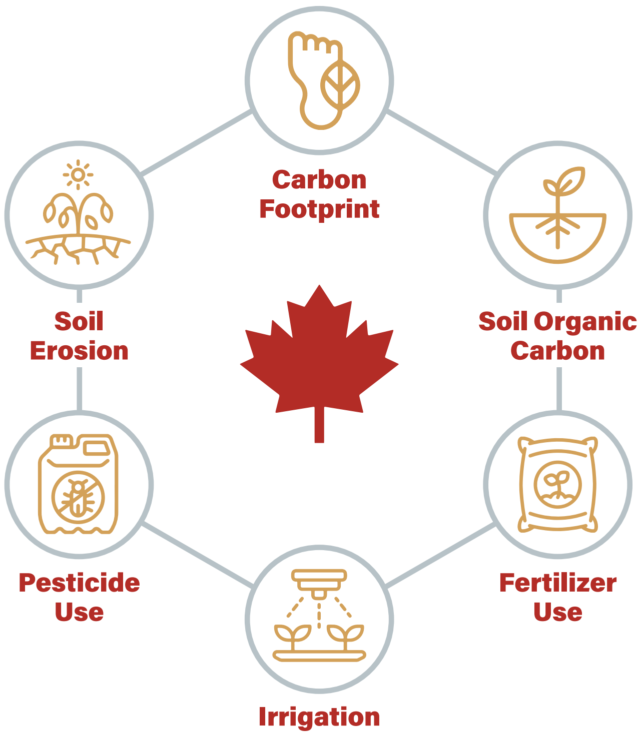
Assessing the Sustainability of Canadian Barley

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).

Barley is an ancient cereal grain that has been grown and consumed for thousands of years. In North America, barley is a major crop used for animal feed as well as for malt for brewing. Critically, barley is a stress tolerant crop that has substantial potential to address sustainability challenges (Newton et al., 2011). Canadian barley is seeded to over 7.3 million acres, with a 5-year average annual production of almost 9 million tonnes (Statistics Canada, 2025). In the 2023-24 crop year, Canada exported 2.3 million tonnes of barley, making it the fourth largest exporter of malt barley (International Grains Council, 2025).

To evaluate the environmental sustainability of Canadian barley 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 barley 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, barley-specific data were used when possible, however, when data availability precluded this, the authors have indicated when general cropland level data were used. The selected indicators were then applied to two other major barley producing regions, Australia and France, to comparatively evaluate the sustainability of Canadian barley production. The direct comparison of environmental indicators between nations is challenging because of regional differences in 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 barley production in a broader context.

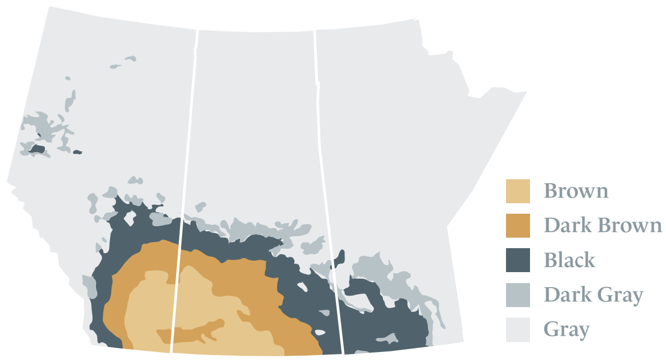
Figure 1 Six indicators to evaluate the sustainability of Canadian barley production relative to production of barley in Australia and France.



Barley is primarily grown in the Western Canadian provinces of Alberta and Saskatchewan, with small areas of production in Manitoba and British Columbia. In general, the barley 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

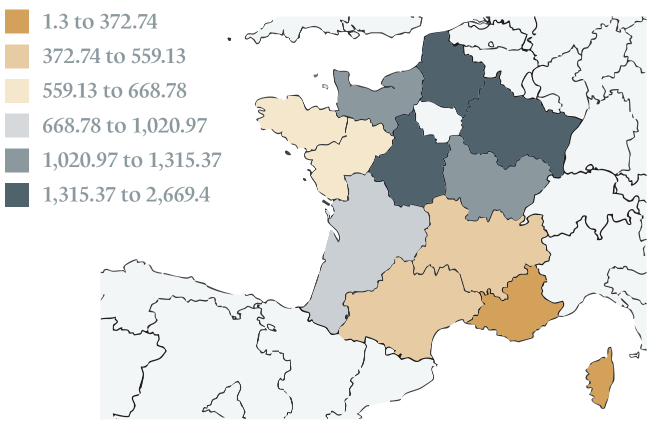
Soil Zones of Western Canada



Map 3

Barley Production France

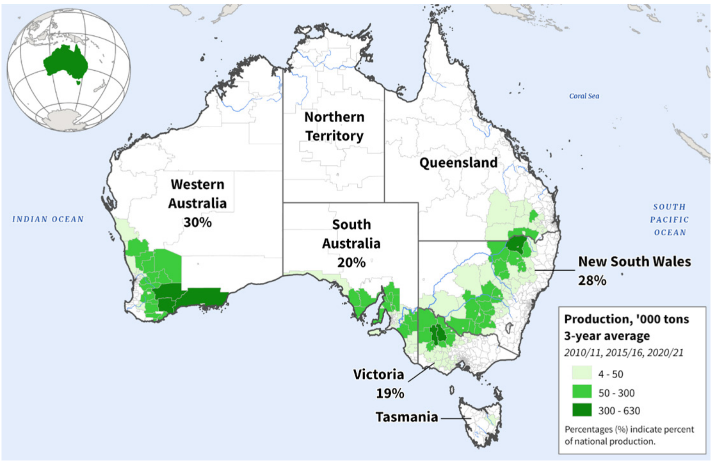
Total Area (hectares)



Barley is primarily cultivated in central and northern France, centred around the Paris basin, which is characterized by a temperate climate with long, warm summers and short, cool winters. The majority of soils fall into four categories: fertile brown soils, sandy soils, degraded alfisols, and alfisols, with agricultural soils used for cereal crops generally being high in silt (Nuria et al., 2011).

Map 4

Barley Production Australia



In Australia, barley is grown from southern Queensland to Western Australia and therefore a wide range of soil types. Black, grey, and brown vertosolic soils with high fertility dominate the crop production regions in the East, whereas low fertility sandy soils dominate the agricultural zones of the southwest. Similarly, the climate ranges from semiarid to subtropical in Queensland to Mediterranean in Western Australia (Soil Quality, 2024).

The Carbon Footprint of Canadian Barley Production and Soil Organic Carbon Sequestration

The range of carbon footprints for barley production in Canada, Australia and France are comparable when soil organic carbon (SOC) sequestration is not included for Canadian croplands (Table 1). However, the carbon footprint of Canadian barley production is generally reduced when accounting for SOC sequestration.

Table 1 Range of average carbon footprints of barley production per tonne of grain for Canada, Australia, and France with and without accounting for soil organic carbon (SOC) sequestration.

Product	Net Emissions (kg CO_2e per tonne)
Canadian Barley	252 – 430 (CRSC, 2021; Desjardins, 2016; Gan et al., 2012)
Canadian Barley (with SOC)	167 – 225 (CRSC, 2021; Desjardins, 2020)
Australian Barley	198 – 340 (Sevenster et al., 2022; Simmons et al., 2019)
Australian Barely (with SOC)	n.d.
French Barley	320 – 750 (AgriBalyse, 2024; Tuomisto et al., 2014; Tidaker et al., 2016)
French Barley (with SOC)	n.d.

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 our 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 barley production to the storage bin.

Soil organic carbon (SOC) sequestration is the process through 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. Thus, 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 CO_2 emissions (Ozlu et al., 2022).

In addition to offsetting 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). 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).

The comparable carbon footprint of Australian barley is indicative of similar production practices and input efficiency between the two systems. The greater range in the carbon footprint for French barley is the result of greater N_2O emissions from higher nitrogen fertilizer application rates, as well as higher energy use for soil tillage activities (Bamber et al., 2023).

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 carbon changes associated with cropland management in Canada, Australia, and France.

Region	Rate of SOC change[L] (Mg CO_2 per ac per yr)
Canada	0.13 (ECCC, 2024)
Australia	0.01 (Australian Government, 2024)
France	-0.03 (CITEPA, 2022)

[L] *Negative values denote losses of SOC (i.e., source of CO_2), positive values indicate net SOC sequestration (i.e., sink of CO_2)*

† *These values represent country-wide average SOC change.*

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 approximately 37% of the barley in Canada (He et al., 2021; McConkey et al., 2020, Statistics Canada, 2025).

In comparison, Australian agricultural soils are net 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).

Similarly, calculations estimating the carbon inputs and outputs of cropland soils in France are characterized by negative carbon balances, thus SOC in these soils is on a decreasing trend. In some areas where organic amendments are high, the carbon budget may be closer to neutral, however, few estimates based on comprehensive data for French croplands exist. Therefore, there is still considerable uncertainty regarding the effects of French agricultural practices on SOC levels (Martin 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 inefficient 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 barley production in Canada, Australia, and France.

Table 3 Average application rates of nitrogen (N), phosphorus (P) and potassium (K) for barley production in Canada, Australia, and France 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	4
Australia	30	23	2
France	120	16	5

Application rates of N, P, and K for barley production are generally highest in France, followed by Canada, and lowest in Australia, which is consistent with differences in production practices. High N fertilizer rates contribute primarily to France having the highest average barley yields per acre (Schauberger et al., 2018). Conversely, Australian cropping systems are generally fertilized at much 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 croplands in Canada, Australia, and France from OECD (2023).

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

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 France from EPI (2022).

Region	SNMI
Canada	67.3
Australia	42.9
France	65.2

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 poor performance on the SNMI scale (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). Therefore, the vast majority of barley production in Canada is rain fed, and only a small proportion of barley is grown under irrigation in Alberta. Approximately 70% of the irrigated area in Canada is located in Alberta (Government of Alberta, 2024). 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 barley production in Canada, Australia, and France.

Region	Irrigation water usage (GL per year) [L]
Canada	95 – 115 (Statistics Canada, 2023, 2024)
Australia	95 – 180 (Australian Bureau of Statistics, 2022, 2023)
France	91 – 148 (Eurostat 2014, 2023; OECD, 2019)

[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 in Australia (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 barley production is rainfed in Australia, and thus irrigation water withdrawals are minimal compared to other crops (Ridoutt and Poulton, 2009).

In France, approximately 6% of farmland is irrigated (OECD, 2016). Irrigation is applied to a variety of crops, but the proportion of irrigation for cereal production is dominated by maize (more than 45%), whereas all other cereals (including barley) account for less than 20% of total irrigation withdrawals (Eurostat, 2014). Current concerns of water resource vulnerability and water use conflict are central to discussions of irrigation policy in France; however, irrigation remains a key option for mitigating production risk and meeting demands for agricultural products (Molle et al., 2019).

Pesticide Use

The term pesticide includes 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 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). Our ability to sustainably increase crop yield and close existing yield gaps depends on this intensification and assessing the net impact of pesticides must consider that pesticides decrease the need for other weed control methods such as tillage, thus increasing SOC retention and reducing fossil fuel use (Duke, 2020; Krimsky, 2021; Damalas and Eleftherohorinos, 2011).

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 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 France is subject to comparable label application rates for analogous products, reflecting similar usage guidelines between the three countries (Table 7).

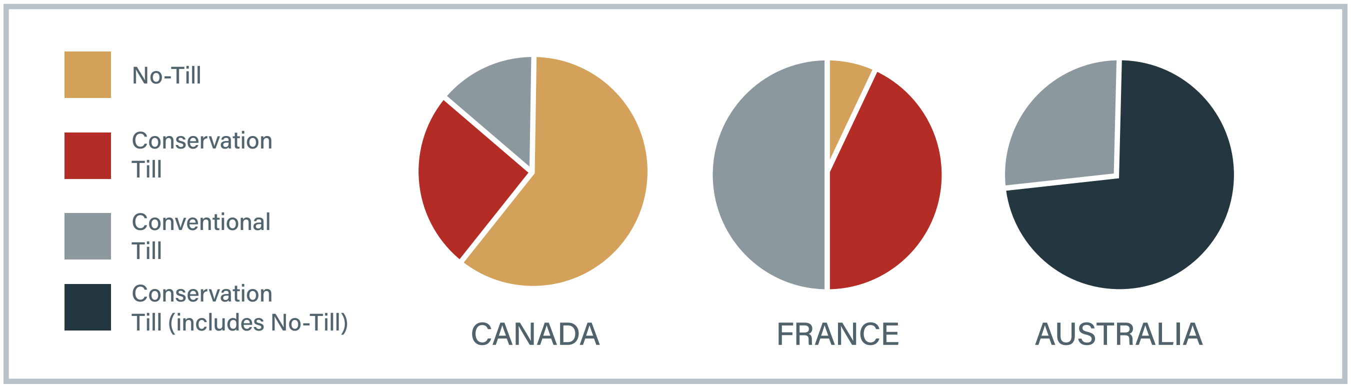
Table 7 Label use rates for cropland for comparable glyphosate-containing products in Canada, Australia, and France

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.)
France	Roundup Evolution Roundup FLASH plus	0.40 – 2.57 (Bayer France, n.d.)

Soil Erosion

Conservation management practices on agricultural lands include, but are not limited to, conservation tillage (i.e., minimum, mulch, or no-tillage), diversification of crop rotations, and cover cropping (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). In Canada, 96% of barley is primarily grown in the prairie provinces of Alberta, Manitoba, and Saskatchewan (Statistics Canada, 2025).

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



Over the past 25 years, producers on the Canadian Prairies have transitioned away from using tillage as the dominant form of weed control, and now over two-thirds of the Canadian prairie provinces are under conservation tillage practices. This has contributed to soil in Western Canada moving from being a net emitter of carbon to sequestering carbon as SOC (Sutherland et al., 2021). Additionally, crop rotation is practiced by more than 95% of producers (Statistics Canada, 2024). In combination with minimum or no-till, crop rotation practices adopted by producers in Canada have maintained or enhanced soil health (Awada et al., 2021). Minimizing tillage and rotating crops are two practices proven to improve soil biological, physical, and chemical properties for plant development, including (but not limited to) increasing levels of soil organic matter, total N, soil biological activity, and soil physical quality parameters such as water infiltration rate (Congreves et al., 2015)

Conservation tillage adoption statistics are similar for Australia. According to the Australian government, approximately 68% of farms minimize tillage (ABERES, 2024; Llewllyn and Ouzman, 2020). Conversely, full tillage is still the dominant form of weed control and seedbed preparation in the European Union (EU). Within the EU, France is a leader in conservation tillage adoption, with approximately 45% of producers opting for conservation tillage practices, of which less than 10% is no-till (Figure 2) (Eurostat, 2020b).

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 Cropland soil erosion rates based on measured and modelled data for Canada, Australia, and France.

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 (Government of Western Australia, 2013; Tan et al., 2021; Zhang, 2022a).
France	Average cropland erosion rate of 0.8 t per ac per yr. (Eurostat, 2020a).

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 minimize erosion risk under a drying climate (OECD, 2015).

Erosion is an issue in intensive agricultural areas in France, namely via sheet and ephemeral gully erosion on soil crusted areas that have limited infiltration capacity, as well as rill erosion on spring sown hillslopes (Le Bissonnais et al., 2002; Le Bissonnais et al., 2005). Since 2010, increased adoption of conservation management practices has resulted in decreased erosion rates on arable lands, but a more incisive set of regionally suited measures of soil conservation is needed to substantially mitigate soil erosion across the EU (Panagos et al., 2020).

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 barley. 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 CO_2 sink. Because of this, the carbon footprint of barley production in Canada is very low. Additionally, Canadian barley 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 minimize soil erosion and protect soil health.

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