Agricultural Greenhouse Gas Emissions in Saskatchewan: A Comprehensive Assessment

National Farmers Union, October 2023

Table of Contents

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Suggested citation: John Mills, Darrin Qualman, and National Farmers Union, *Agricultural Greenhouse Gas Emissions in Saskatchewan: A Comprehensive Assessment* (Saskatoon: NFU, October 2023).

For more NFU analysis and an exploration of emission-reduction solutions, please see:

- *Agricultural Greenhouse Gas Emissions in Canada: A New, Comprehensive Assessment*, Third Edition, 2023
- *Tackling the Farm Crisis and the Climate Crisis*, 2019, and
- *Imagine If.... A Vision of a Near-Zero-Emission Farm and Food System for Canada*, 2021.

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Introduction

This report presents a single detailed picture of nearly all sources of greenhouse gas (GHG) emissions from Saskatchewan agricultural production and production of associated farm inputs. See Figure 1. Saskatchewan has a central place in Canadian agriculture, with roughly 40% of Canada's cropland, 20% of Canada's cattle herd, and almost 30% of Canada's GHG emissions from agriculture. Thus, a comprehensive, fine-grained picture of agricultural emissions in Saskatchewan is crucial to farmers' and policymakers' efforts to reduce emissions from Canadian agriculture as a whole.

This report builds on previous work by the NFU to compile comprehensive information on greenhouse gas emissions from Canadian agriculture.[1] Please refer to the most recent edition of those reports for a more detailed description of each category of emissions as well as methodological notes and sources.

Canada has committed to reduce economy-wide GHG emissions by at least 40 percent by 2030 and to reach net zero by 2050. Specific to agriculture, the federal government has committed to work with farmers and industry to reduce emissions from fertilizer use to 30 percent below 2020 levels by 2030[2] and to reduce methane emissions from livestock production as part of Canada's larger pledge to reduce *overall* methane emissions to 75 percent below 2012 levels by 2030.[3] Big changes are coming, fast, for every sector of the Canadian economy, including farming.

To properly plan and implement the many on-farm changes needed to achieve emissions reductions and to design and fund the government programs needed to accelerate and *support* those on-farm changes, farmers and policymakers need to understand emissions: we need detailed, comprehensive numbers. In almost all cases, however, the data is presented in incomplete and inadequately detailed formats. Many analyses omit key emission sources such as farm fuel use or input production. Clear, accessible, *complete* analyses and graphs are often lacking. This report is a contribution to filling that gap.

Many current analyses omit key agricultural emissions data because they are based on categorization schemes stipulated by the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) or UN Framework Convention on Climate Change (UNFCCC)—categorizations that lead to a reporting of only a subset of agricultural emissions, most often including those from:

1. livestock enteric fermentation, i.e., digestion of grass and forage (methane, CH_4);
2. manure management (methane, CH_4, and nitrous oxide, N_2O);
3. agricultural soils, including emissions triggered by the addition of synthetic nitrogen fertilizer and manure (nitrous oxide, N_2O);
4. burning of crop residues (methane, CH_4, and nitrous oxide, N_2O, but not carbon dioxide, CO_2); and
5. urea fertilizer, other carbon-containing fertilizers, and lime (carbon dioxide, CO_2).

IPCC/UNFCCC-based reporting categorizes emissions from the production of machinery and fertilizer under "industrial processes and product use," not agriculture. Emissions from farm fuel and electricity use are reported under the categories "transport" and "energy," respectively. To form the basis for planning on-farm emission-reduction measures or government policies or programs, more detailed and complete assessments are needed. Such assessments are presented on the next page.

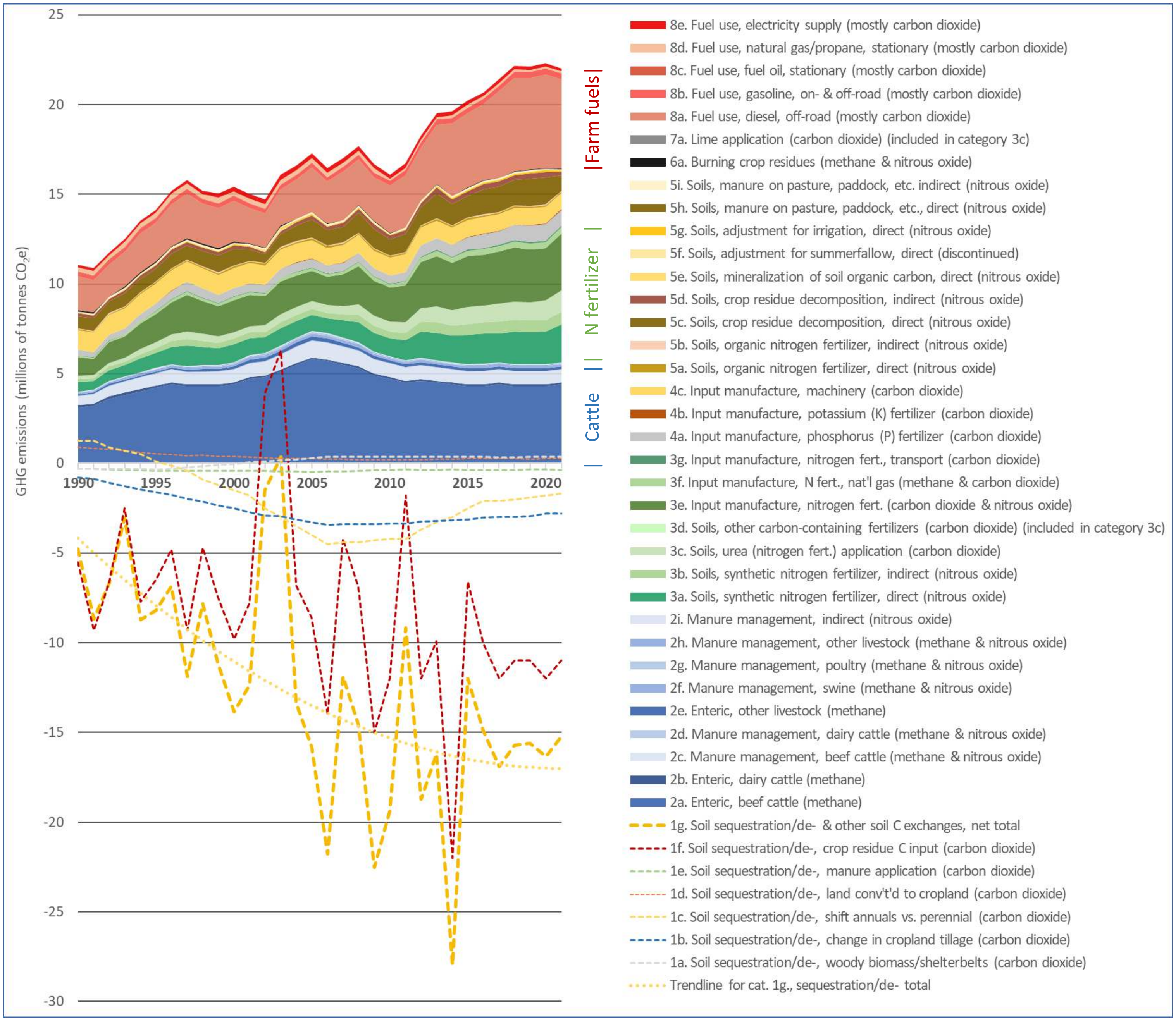
1 Darrin Qualman and National Farmers Union, "Agricultural Greenhouse Gas Emissions in Canada: A New, Comprehensive Assessment," Third Edition, August 2023.

2 Environment and Climate Change Canada, "A Healthy Environment and a Healthy Economy: Canada's Strengthened Climate Plan to Create Jobs and Support People, Communities and the Planet" (Ottawa: ECCC, December 2020), https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf.

3 Environment and Climate Change Canada, "Canada to Launch Consultations on New Climate Commitments This Month, Establish Emissions Reduction Plan by the End of March 2022," news releases, December 3, 2021, https://www.canada.ca/en/environment-climate-change/news/2021/12/canada-to-launch-consultations-on-new-climate-commitments-this-month-establish-emissions-reduction-plan-by-the-end-of-march-2022.html.

Part 1. A comprehensive, detailed picture of agricultural GHG emissions

Figure 1, below, presents a comprehensive picture of Saskatchewan agricultural emissions and soil-atmosphere fluxes.



CO_2 = carbon dioxide CO_2e = carbon dioxide equivalent N_2O = nitrous oxide CH_4 = methane (natural gas) NH_3 = ammonia fertilizer   Mt = million tonnes

Figure 2, below, provides a comparison of agricultural emissions and soil-atmosphere fluxes between Saskatchewan (left) and Canada as a whole (right). The legend is the same as for Figure 1, above.

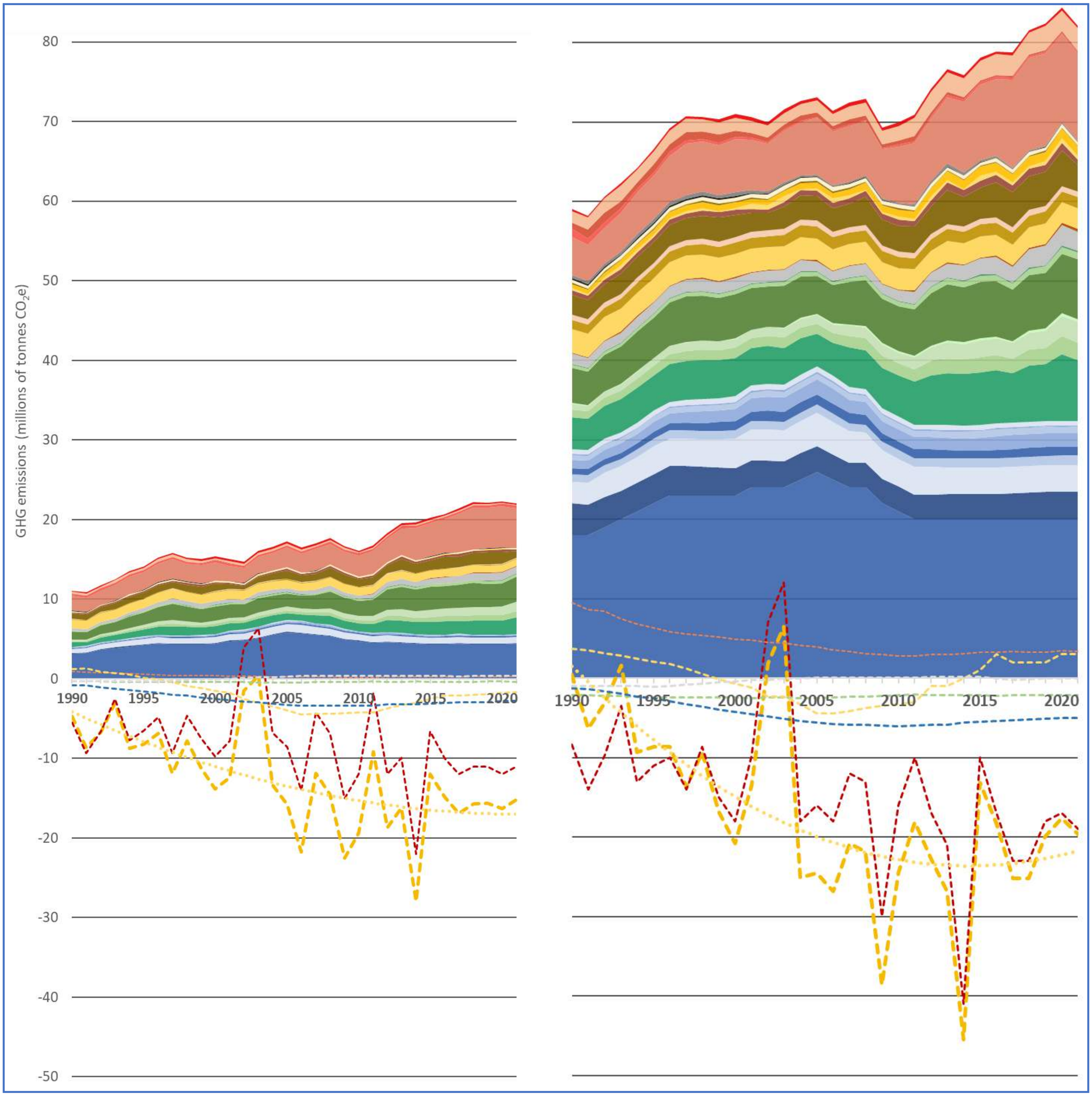


Figure 2. Comparison of Saskatchewan (left) and Canadian (right) agricultural emissions and fluxes, 1990–2021
Sources: ECCC, National Inventory Report 1990–2021, Part 1, Tables 5-1, 6-1, and 6-9 (with data for years omitted from the Tables provided by ECCC); Additional data and sub-categorizations of published data provided by ECCC upon request; ECCC, Common Reporting Format (CRF) Tables; Data from Dyer et al.; other sources; and NFU own calculations. The vast majority of categories are based on ECCC NIR data.

Part 2. A high-level analysis of Saskatchewan agricultural emissions and trends

In this Part, we provide general observations on some of the major components of the emissions depicted in Figure 1.

A. Saskatchewan agricultural GHG emissions are rising

The graph's top line rises from 11.1 million tonnes (Mt) carbon dioxide equivalent (CO_2e) in 1990 to 22.0 Mt in 2021[4] (i.e., agricultural emissions roughly doubled over the thirty-one-year period). Over a more recent period, agricultural emissions are up from 17.3 Mt in 2005—Canada's reference year for its international commitments. These emission values do not include adjustments for soil carbon sequestration or other carbon/CO_2 exchanges between soils and the atmosphere.

B. Nitrogen fertilizer is the largest source of Saskatchewan agricultural GHG emissions

In 2021, total net GHG emissions related to nitrogen fertilizer were 7.6 Mt CO_2e—making this the largest emissions source for Saskatchewan agriculture. Emissions from the production and use of nitrogen fertilizer are recorded in seven categories:

- 3a. Direct emissions from farm fields (nitrous oxide, N_2O);
- 3b. Indirect emissions—off-site and delayed emissions from nitrogen fertilizer runoff, leaching, or volatilization (N_2O);
- 3c. Emissions from the carbon in granular urea fertilizer (carbon dioxide, CO_2);
- 3d. Emissions from the carbon in some other nitrogen fertilizers (CO_2)[5];
- 3e. Emissions from nitrogen fertilizer production facilities (mostly CO_2, but also N_2O);
- 3f. Upstream emissions from the production and processing of the natural gas used in the production of nitrogen fertilizer (methane, CH_4, and CO_2); and
- 3g. Emissions from transport of fertilizer to distribution and retail facilities and onward to farms (mostly CO_2).

C. Emissions from nitrogen fertilizer use are continuing to rise

To a significant extent, the top line of Figure 1 is rising because nitrogen-fertilizer-related emissions are rising. Emissions from nitrogen fertilizer production and use have *tripled* since 1990, driven by rising application rates and tonnage. As Figure 3 shows, nitrogen fertilizer consumption in Saskatchewan has more than quadrupled since 1990. For further analysis of the important and problematic role of nitrogen fertilizer in agriculture, please read the NFU's 2022 report on that subject.[6]

4 Unless otherwise specified, emissions units are millions of tonnes of carbon dioxide equivalent per year, i.e., Mt CO_2e per year.

5 National data from the CRF tables disaggregates liming, urea, and other carbon containing fertilizers. However, liming data is confidential at the provincial level, so this report groups the thee categories together. As most of the emissions from these categories can be attributed to urea in Saskatchewan, the three categories are all attributed to 3c, recognizing that this understates emissions from other carbon containing fertilizers and liming.

6 Darrin Qualman and the National Farmers Union, "Nitrogen Fertilizer: Critical Nutrient, Key Farm Input, and Major Environmental Problem," August 2022.

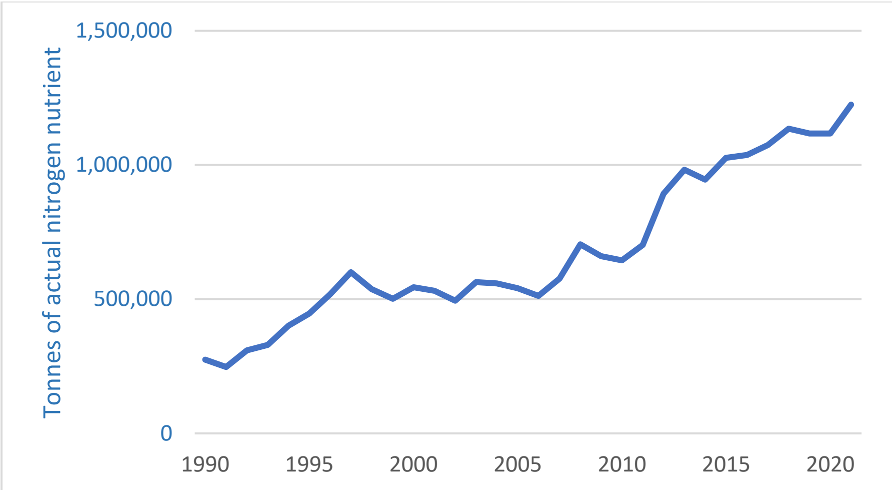


Figure 3. Saskatchewan nitrogen fertilizer consumption, actual N nutrient, 1990–2021.
Sources: Statistics Canada Tables 32-10-0039-01 and 32-10-0274-01.

D. Rising emissions from fuel use also contribute to increasing total emissions

Fuel use is the second largest category of Saskatchewan agricultural GHG emissions: 5.6 Mt CO_2e in 2021. This is an 120% increase from emissions of roughly 2.5 Mt in the early 1990s.

In Figure 1, emissions from farm fuel and energy use are divided into five categories (all mostly CO_2):

- 8a. diesel fuel, off-road only (farmers' on-road diesel use would add very little, especially as we have set the boundary for this analysis at the farm gate, i.e., excluding post-farm road transport);
- 8b. gasoline, on- and off-road;
- 8c. fuel oil, light and heavy, for stationary uses;
- 8d. natural gas and propane for stationary applications such as building heating and grain drying; and
- 8e. emissions from the fossil-fuel-fired electricity-generating stations that supply many farms in Saskatchewan.

E. Manufacturing of fertilizers and other farm inputs is significant and thus so too are fossil fuels and CO_2

This report and its graphs and tables include emissions from the production of four types of farm inputs[7]:

- phosphorus fertilizer (category 4a);
- potassium fertilizer (4b);
- nitrogen fertilizer (3e, 3f, and 3g); and
- farm machinery (4c).

Farm input production is a significant part of overall agricultural emissions. Adding up all emissions from the production of agricultural machinery and fertilizers yields a total of 5.4 Mt CO_2e per year or 24.6 percent of total agricultural emissions.[8] Moreover, much of this is CO_2 from fossil fuels. When we add these emissions to those from farm fuel and energy use (another 25.4 percent of total emissions), we begin to see that half of total agricultural emissions in Saskatchewan are related to fossil fuels and CO_2.[9] This is a different picture than the one often presented wherein almost all agricultural GHGs are methane and nitrous oxide. Though these latter gases are central to the project of reducing agricultural emissions,

7 It is likely that these four account for the bulk of emissions from the production/manufacturing of all farm inputs. Nonetheless, future editions of this report may be able to add categories for the manufacturing of pesticides, plastics, etc.
8 This is based on the sum of categories 3e, 3f, 3g, 4a, 4b, and 4c. Categories 3c and 3d are excluded.
9 The total would be much more than half if CO_2 from in-field hydrolysis of urea and UAN nitrogen fertilizer were included, and there are arguments for doing so because the C in that CO_2 is derived from fossil fuels and added in fertilizer production facilities.

it is a mistake to think that reducing fossil-fuel-related CO_2 emissions is not equally important. Fossil fuels are, by far, the largest input into Saskatchewan food production systems.

Further, it may be that the *largest* portion of agricultural emissions reductions will eventually come from reductions in fossil-fuel use. Consider: Reducing enteric methane emissions from livestock by even 30 percent will be challenging. Similarly, reducing emissions from fertilizer use by 30 percent is possible, but it is hard to see how we can achieve, say, double that reduction. In contrast, it should be possible, as we move through the 2030s, 2040s, and beyond, to slash CO_2 emissions from fossil fuel and energy use—from manufacturing, mining, and other industrial processes; from the heating of farm homes and buildings; and, later and with more challenges, from farm machinery. Though perhaps a lower priority for agricultural emission reduction today, fossil fuel use may eventually yield the *largest* reductions.

F. Cattle are a significant source of Saskatchewan agricultural GHG emissions

Emissions directly attributed to cattle—which, in Saskatchewan, come almost entirely from beef cattle—totalled 5.3 Mt CO_2e in 2021 and are reported in four categories:

2a. Enteric, beef cattle (CH_4);
2b. Enteric, dairy cattle (CH_4);
2c. Manure management, beef cattle (N_2O and CH_4); and
2d. Manure management, dairy cattle (N_2O and CH_4).

G. Emissions directly attributed to cattle are declining

Emissions attributed to cattle have been declining since 2005, as the size of the herd has declined. Figure 4 shows cattle numbers in Saskatchewan. Note how the shape of the top line echoes the shape of the emissions curves at the bottom of Figure 1. Efficiency gains have also helped decrease emissions.

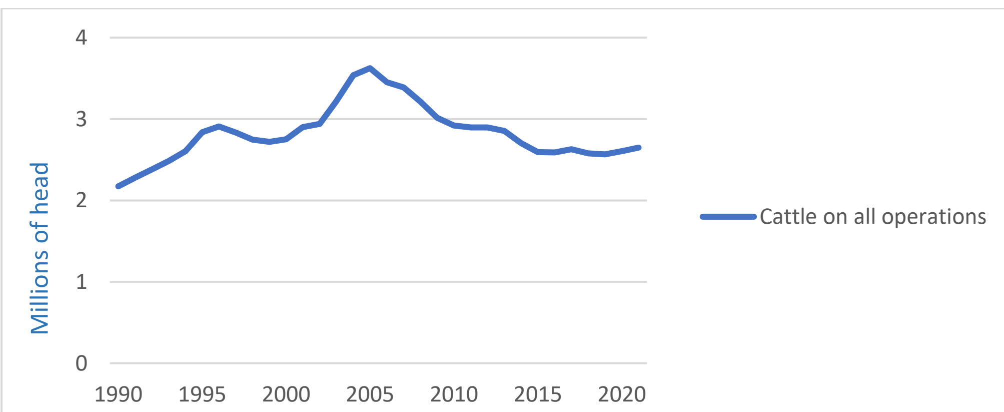


Figure 4. Cattle on farms in Saskatchewan, 1990–2021.
Source: Statistics Canada Table 32-10-0130-01.

While cattle were the largest source of GHG emissions in Saskatchewan from 1990 to 2011, they were overtaken by nitrogen fertilizer in 2012, then again by fuel use in 2017 and input manufacturing in 2018. For Canadian agriculture as a whole however, cattle continue to be the largest single source of emissions.[10]

Had cattle numbers in Saskatchewan remained near 2005 levels, or had numbers continued to rise as they did in the 1990-to-2005 period, overall agricultural emissions today (the top line in Figure 1) would

10 Darrin Qualman and National Farmers Union, "Agricultural Greenhouse Gas Emissions in Canada: A New, Comprehensive Assessment," Third Edition, August 2023.

be around 25 Mt CO_2e per year, rather than at 22 Mt. Declining emissions from cattle serve to countervail rapidly rising emissions from nitrogen fertilizer and farm fuel use—moderating the overall rate of increase in agricultural emissions. Again, though, even with this moderating effect, emissions from Saskatchewan agriculture and input production have doubled.

H. There is no clear boundary for quantifying livestock-related emissions

Enteric and manure-management-related emissions for cattle totalled 5.3 Mt CO_2e in 2021. It is easy to think of those as comprising "emissions from cattle" and to think of nitrogen-related emissions or similar categories as "emissions from the crop sector." But, of course, a large portion of the Saskatchewan crop is feedgrain and a significant portion of total farm fuel is used in beef and dairy production. Hence, a significant portion of nearly every category in Figure 1 could be counted toward emissions from cattle.

Similarly, in Figure 1, emissions from other livestock (poultry, hogs, etc.) appear to be small—totalling just 0.3 Mt CO_2e per year, mostly from manure management. However, these values omit emissions from feedgrain production—emissions reported in categories such as 3a: N_2O emissions from soils as a result of synthetic nitrogen application. Feedgrain-related emissions probably make up the bulk of emissions related to pork and poultry meat production, thereby obscuring the emissions footprint from these production systems.

This report does not seek to assail livestock production. To the contrary, livestock can be vital parts of biodiverse, nutrient-cycling ecosystems—core to regenerative agriculture, agroecology, mixed farming, and a range of solutions we would be wise to consider. For example, cattle can enable us to produce food on land that should not be cropped, and cattle or other ruminants are crucial to healthy grassland ecosystems. As the NFU details in its report *Tackling the Farm Crisis and the Climate Crisis*, having grazing animals on the landscape is *natural* and *beneficial*.[11] Please read that report for a balanced view of the place of cattle in the sustainable agroecosystems of the future. That said, however, we must also acknowledge that emissions from livestock production go far beyond manure and enteric emissions; encompass millions of tonnes reported under fertilizer and energy use; and are very high. These high emissions mean that we must make changes to livestock production systems if we are to reduce overall agricultural emissions in line with Canada's commitments and planetary limits.

I. Land use changes, carbon exchanges, and soil sequestration

The preceding focuses on agricultural greenhouse gas *emissions*. In addition to these emissions, there are also *exchanges* of carbon/CO_2 between the atmosphere and agricultural soils—some going one direction and some going the opposite. The most oft-mentioned example is soil carbon sequestration as a result of reductions in tillage: "no-till," "zero-till," "direct seeding," or even "strip tillage."

Opinions differ regarding how to *account* for these exchanges.[12] Some people advocate subtracting the tonnage of these soil-atmosphere carbon/CO_2 exchanges from the emissions outlined above—suggesting that we net out roughly 15 million tonnes of soil carbon sequestration against the 22 million tonnes of GHG emissions to create a measure of "net emissions." Others, however, believe that there are good reasons *not* to do so. Drawing on extensive published science and expert opinion, the NFU has detailed why GHG emissions and soil-atmosphere exchanges (including soil carbon sequestration resulting from reduced tillage) should be kept separate when doing GHG accounting (see the NFU's 2021 submission to

11 Darrin Qualman and the National Farmers Union, "Tackling the Farm Crisis and the Climate Crisis: A Transformative Strategy for Canadian Farms and Food Systems", discussion document, 2019.

12 A distinction can be made between emissions *reporting* (quantifying tonnage) and emissions *accounting* (which adds in an element of interpretation or an assignment to larger categories).

ECCC[13]). While soil carbon gains are *extremely* positive and contribute to ecosystem integrity, soil health, water retention, drought resilience, and climate adaptation, soil carbon gains should not be seen as offsetting, zeroing out, or otherwise erasing actual emissions, especially those from fossil fuels.

Nonetheless, carbon/CO_2 exchanges between soils and the atmosphere as a result of changes in agricultural practices and increases in biomass inputs are large—totalling millions of tonnes per year. Taking our cues from ECCC, Figure 1 quantifies these exchanges in six categories (all CO_2):

1a. Changes in woody biomass incl. additions or removals of tree rows, shelterbelts, etc.;
1b. Changes/reductions in tillage of croplands;
1c. Shifts in the balance between perennial and annual crop area;
1d. Land converted to cropland (mostly forest land cleared for farming);
1e. Manure application; and
1f. Crop residue carbon input.

Below are two tables corresponding to Tables 6-1 and 6-9—respectively—from the 2023 NIR, Part 1. Negative values denote carbon/CO_2 flowing from the atmosphere into agricultural soils (sequestration) and positive values denote carbon/CO_2 flowing from agricultural soils to the atmosphere (desequestration). Note the very large negative values for "Crop residue C input."

Saskatchewan LULUCF Sector Net GHG Flux Estimates, Selected Years

Sectoral Category		Net GHG Flux (kt CO2 eq)[a]						
		1990	2005	2017	2018	2019	2020	2021
b.	**Cropland**	**-4700**	**-16000**	**-17000**	**-15000**	**-15000**	**-16000**	**-15000**
	Cropland Remaining Cropland	-5600	-16000	-17000	-15000	-15000	-17000	-15000
	Land Converted to Cropland	920	260	270	280	240	260	280
c.	**Grassland**	**0.049**	**0.029**	**0.31**	**0.31**	**0.31**	**0.31**	**0.31**
	Grassland Remaining Grassland	0.049	0.029	0.31	0.31	0.31	0.31	0.31
	Land Converted to Grassland	NO	NO	NO	NO	NO	NO	NO
d.	**Wetlands**	**38**	**68**	**41**	**44**	**47**	**52**	**52**
	Wetlands Remaining Wetlands	22	68	41	44	47	52	52
	Land Converted to Wetlands	16	0.37	0.057	0.057	0.057	0.057	0.057

Base and Recent Year Emissions and Removals Associated with Various Land Management Changes on Cropland Remaining Cropland in Saskatchewan

Categories	Land Management Change (LMC)	Emissions/Removals (kt CO_2)[a]						
		1990	2005	2017	2018	2019	2020	2021
Total Cropland Remaining Cropland		**-5600**	**-16000**	**-17000**	**-15000**	**-15000**	**-17000**	**-15000**
Cultivation of histosols		9.2	9.2	9.2	9.2	9.2	9.2	9.2
Perennial woody crops		-320	290	310	330	360	360	360
Total mineral soils		**-5300**	**-16000**	**-18000**	**-16000**	**-16000**	**-17000**	**-16000**
Change in crop mixture	Increase in perennial	-760	-5600	-5000	-4900	-4800	-4700	-4500
	Increase in annual	2000	1600	2900	2900	2900	2900	2800
Change in tillage	Conventional to reduced	-520	-580	-340	-320	-300	-270	-250
	Conventional to no-till	-280	-2100	-2000	-2000	-2000	-1900	-1900
	Other[b]	-0.02	-590	-650	-650	-650	-640	-640
Crop residual C input		-5500	-8600	-12000	-11000	-11000	-12000	-11000
Manure application		-300	-480	-380	-370	-360	-360	-370
Land conversion—Residual emissions		32	170	170	160	160	160	150

Notes:
NO = Not occurring
a. Negative sign indicates net removals of CO_2 from the atmosphere.
b. Other includes reduced to no-till as well as other changes in tillage with relatively less significant impacts on emissions/removals, namely: reduced to conventional, no-till to conventional, and no-till to reduced

Table 1. Two ECCC/NIR tables showing exchanges of carbon/CO_2 between soils and the atmosphere.
Source: Data provided upon request by ECCC.
Notes: Yellow-highlighted rows indicate categories used in this report.

Note several points about the values in these tables:

13 National Farmers Union, "Submission to the Public Comment Period for the Federal Government's Draft Greenhouse Gas Offset Credit System Regulations" (Saskatoon: NFU, 2021), https://www.nfu.ca/wp-content/uploads/2021/05/Fedl-Regulations-for-Offset-Protocols-NFU-submission-May-2021-Final.pdf.

A. Reductions in tillage, while the most-often discussed category, is not where we see the largest carbon/CO_2 flows. In recent years, tillage-related sequestration has been approximately 3 Mt per year.
B. Crop residue carbon input (which subsumes the now-discontinued category "Reduction in summerfallow area") is a much larger factor in moving carbon/CO_2 from the atmosphere to soils. This category recorded sequestration averaging roughly 11 Mt CO_2e per year in recent years.
C. Changes in the mix of annual versus perennial crops is another factor. Shifts that result in a smaller area of annual crops and a larger area of perennials are reported as net transfers of carbon/CO_2 from the atmosphere to soils. In the table above, the overall balance of those changes in crop mix have resulted in carbon/CO_2 exchanges ranging from -4.0 Mt of net sequestration in 2005 to -1.7 Mt CO_2e in 2021. Saskatchewan is unique in Canada for having continued net sequestration from conversion to perennials in recent years, while other provinces have experienced net desequestration from conversion to annuals. However, Saskatchewan cropland is trending back towards desequestration, as conversions to annuals are whittling down the large area of perennials built up in the 1990s and early 2000s.
D. "Land converted to cropland" (the creation of new farmland, mainly from forest) also creates carbon/CO_2 exchanges—desequestration averaging 0.3 Mt CO_2e per year in recent years.
E. Overall, sequestration—the transfer of carbon/CO_2 from the atmosphere to soils—appears to be declining, though highly variable from year to year. Averaging the most recent five years for which data is available (2017–2021, inclusive) the six categories averaged −16.0 Mt CO_2e per year, i.e., sequestration of that amount. But several years earlier (2010–2014, inclusive), those same six categories together averaged −18.3 Mt—about 14 percent higher.
F. ECCC does not yet report data on carbon/CO_2 desequestration from the destruction of wetlands on agricultural land.[14] If reported, this would be a large source of CO_2. Conversations with experts indicate that soil carbon/CO_2 flows from wetlands destruction on Prairie farmland could total 3 to 4 Mt CO_2e per year.[15] If further research reveals that to be an accurate estimate, values for overall soil carbon sequestration could be significantly lower than those in Figure 1.

14 "*NIR 2022* Part 1," Table 6-4.

15 This estimate includes only carbon losses from soils and does not include increased emissions from subsequent fertilizer and input use or *decreased* emissions from the reduction of farm implement overlap, etc. Most likely, soil carbon losses represent the bulk of overall GHG flows that result from destruction of wetlands.

Concluding remarks

We can be certain of the following: Saskatchewan agricultural emissions are high and rising; the main drivers for the increase are rising rates of synthetic nitrogen fertilizer use and diesel fuel combustion; fossil fuel use is a larger factor than is often acknowledged; and sequestration—though high—is significantly less than emissions on a per-year basis. Thus, the suggestion that Saskatchewan agriculture has achieved net-zero does not account for the full range of GHG emissions, such as input manufacturing.

What is less certain are the exact emissions in most of the categories detailed above. There are significant uncertainties for many of the categories. Much work needs to be done to reduce the uncertainties. For example, NIR data on sequestration relies entirely upon modelled changes due to certain practices, and these models must be assessed against empirical data from widespread and rigorous soil sampling. Reliable data is essential as we endeavour to measure and report emissions reductions from on-farm changes—reductions that will initially be small, though very important to quantify, document, and reward.

Nonetheless, we have more than enough data and more than enough precision to move forward swiftly, energetically, and courageously to reduce agricultural emissions. Commitments by governments to cut emissions from methane, from fertilizer, and from the economy as a whole provide clear signals that we need to act now and in each coming year to reduce emissions from all agricultural categories. Our actions must address the central roles that fossil fuels currently play in Saskatchewan agriculture.

The NFU hopes that this report and its data will help Saskatchewan policymakers and farmers in this important work and, most importantly, inform the creation of sound, effective government policies and programs that can support and assist farmers as they make the needed changes to move to lower-emissions systems.

Key reports and information sources

For those interested in GHG emissions, key documents from the Government of Canada include:

- Environment and Climate Change Canada (ECCC), GHG emission data tables, https://data.ec.gc.ca/data/substances/monitor/canada-s-official-greenhouse-gas-inventory/

- ECCC, *National Inventory Report 1990–2021: Greenhouse Gas Sources and Sinks in Canada*, 2023, https://unfccc.int/documents/627833?gclid=CjwKCAjww7KmBhAyEiwA5-PUSjNOE93sC1lzH65O8nj6hyWaVyyPd0Fj_iHtL9AuJwd_taxfebPXGhoCRxQQAvD_BwE This three-part annual report is the primary source for almost all emissions values. See especially:
    - Part 1, section 2.3.3, Agriculture Sector
    - Part 1, Ch. 5, Agriculture
    - Part 1, Table 5-1, Short-and Long-Term Changes in Emissions from the Agriculture Sector
    - Part 1, Chapter 6, Land Use, Land Use Change, and Forestry

- ECCC, Canada's 8th National Communication and 5th Biennial Report, 2022, https://unfccc.int/sites/default/files/resource/Canada%20NC8%20BR5%20EN.pdf

- ECCC, Canada's Greenhouse Gas and Air Pollutant Emissions Projections 2020, https://publications.gc.ca/collections/collection_2021/eccc/En1-78-2020-eng.pdf