Agricultural Greenhouse Gas Emissions in the Atlantic Provinces: A Comprehensive Assessment

National Farmers Union, February 2024

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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.

All are available at www.nfu.ca

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Introduction

This report presents a single detailed picture of nearly all sources of greenhouse gas (GHG) emissions from agricultural production and production of associated farm inputs for the four Atlantic provinces: New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.[1] See Figure 1.

This report builds on previous work by the NFU to compile comprehensive information on greenhouse gas emissions from Canadian agriculture.[2] 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 data 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[3] and to reduce methane emissions from livestock production as part of Canada's larger pledge to reduce *overall* methane emissions by 2030.[4] 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 Due to data limitations and other considerations, this report groups the four Atlantic provinces together.

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

3 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 .

4 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 details agricultural emissions and soil-atmosphere fluxes in the four Atlantic provinces.

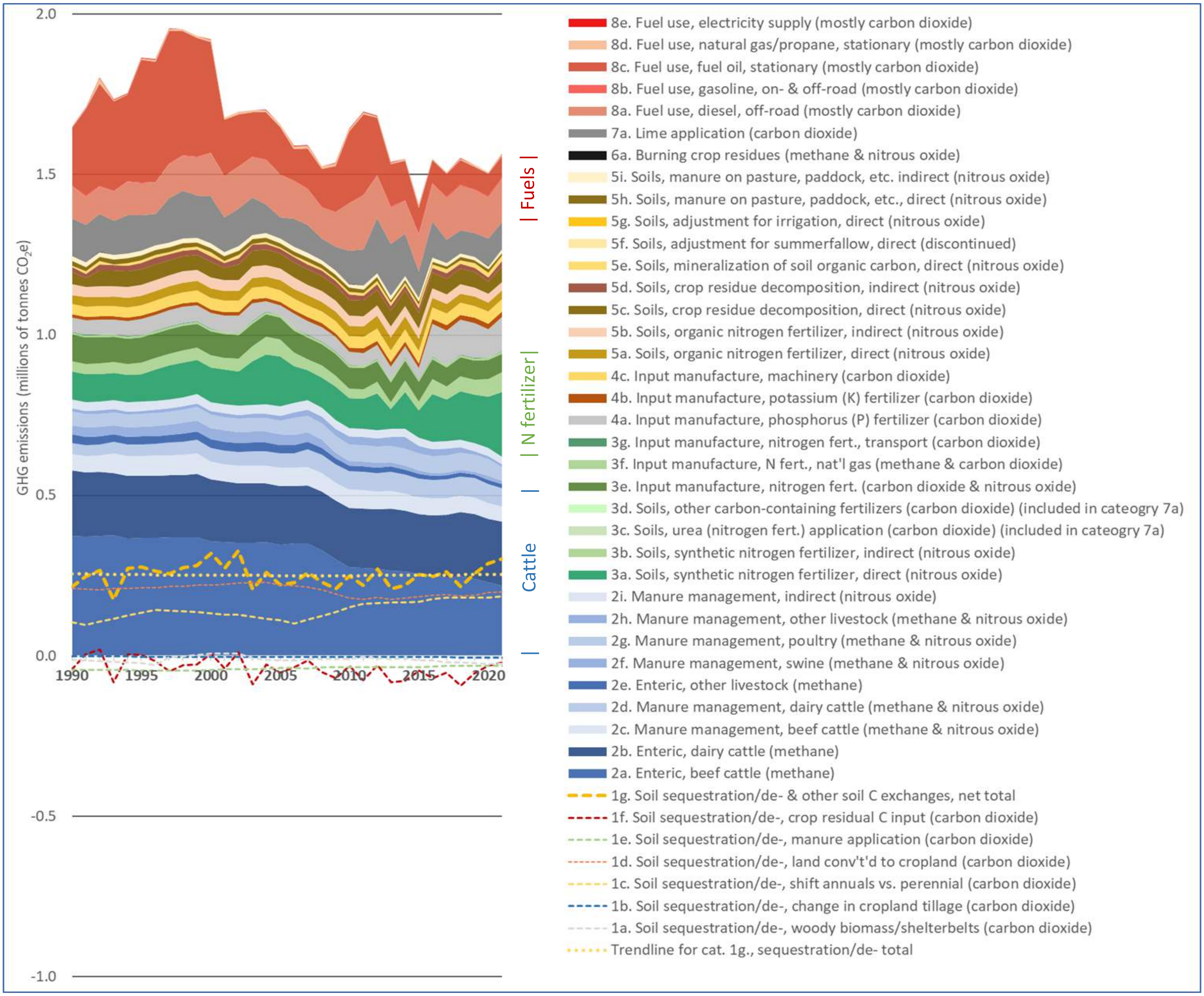

Figure 1. Comprehensive, detailed picture of Atlantic provinces agricultural emissions and fluxes, 1990–2021
Sources: Data provided by ECCC upon request corresponding to National Inventory Report 1990–2021, Part 1, Tables 5-1, 6-1, and 6-9; Additional data and sub-categorizations of published data provided by ECCC upon request; Data from Dyer et al.; other sources; and NFU's own calculations. The vast majority of categories are based on ECCC NIR data. Please see the NFU's report on Canadian agricultural emissions for details of data sources.

Note that in the graph (Figure 1) and other parts of this report we use the term "soil sequestration/de-" to refer to categories that can include sequestration (atmospheric CO_2 captured as soil carbon) and the reverse: *desequestration* (soil carbon released as atmospheric CO_2). A key concept is that this is a *reversible* process: soils can sequester carbon for a time and then changes in farming practices or land use or even climatic conditions (e.g., hotter, drier weather) can cause those soils to release/desequester carbon and later another change can cause them to again sequester, and so on and so on.

Part 2. A high-level analysis of agricultural emissions and trends in the Atlantic provinces

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

A. Overall agricultural GHG emissions in the Atlantic provinces are fairly stable

The graph's top line decreases from about 1.8 million tonnes (Mt) carbon dioxide equivalent (CO_2e) in the 1990s to about 1.5 Mt in recent years[5] (i.e., agricultural emissions fell by roughly 17% over the past three decades). These emission values do not include adjustments for soil carbon sequestration or other carbon/CO_2 exchanges between soils and the atmosphere.

Emissions from agriculture in the Atlantic provinces make up a small fraction of the national total: roughly 2% in 2021. However, while overall emissions from the Atlantic provinces are much smaller than other regions, their emissions intensities—defined here as tonnes of CO_2e per acre of cropland—are similar. For example, the Atlantic provinces had approximately the same emissions intensity as Ontario in 2021: 1.2 tonnes CO_2e per year per acre of cropland.

B. Cattle remain the largest source of agricultural emissions in the Atlantic provinces

Emissions directly attributed to cattle totalled 0.52 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).

Emissions attributed to cattle have been declining since the mid 1990s, as the size of the herd has declined. Figure 2 shows cattle numbers in the Atlantic provinces. Efficiency gains have also helped decrease emissions.

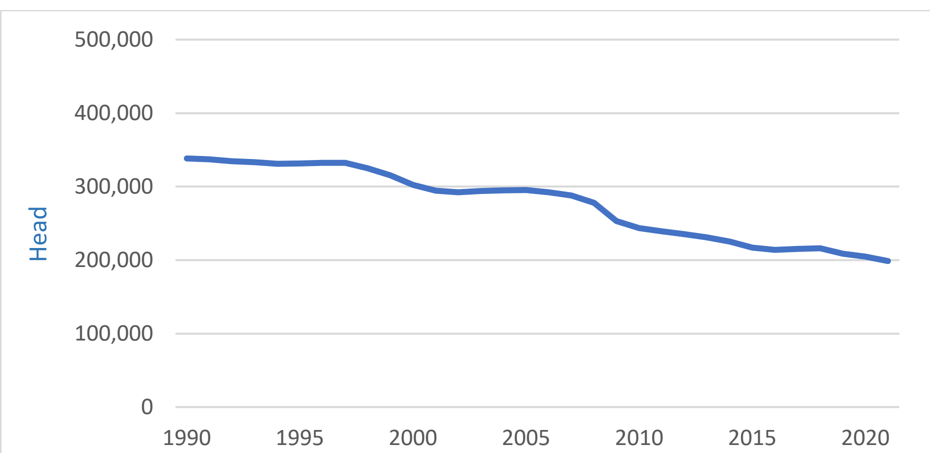

Figure 2. Cattle on farms in the Atlantic provinces, 1990–2021.
Source: Statistics Canada Table 32-10-0130-01.

Had cattle numbers in the Atlantic provinces stayed at mid-1990s levels, overall agricultural emissions today (the top line in Figure 1) would be around 1.7 Mt CO_2e per year, rather than approx. 1.5 Mt. Declining emissions from cattle serve to countervail rising emissions from nitrogen fertilizer.

5 Unless otherwise specified, emissions units are millions of tonnes of carbon dioxide equivalent per year, i.e., Mt CO2e per year.

C. Emissions from non-cattle livestock in the Atlantic provinces are larger than they appear

Emissions from other livestock (hogs, poultry, etc.) appear to be small—totalling just 0.07 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.

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

It is easy to think of emissions from enteric fermentation and manure management as comprising "emissions from livestock" and to think of nitrogen-related emissions or similar categories as "emissions from the crop sector." But, of course, a large portion of crops is feedgrain and a significant portion of total farm fuel is used to raise animals. Hence, a significant portion of nearly every category in Figure 1 could be counted toward emissions from livestock. This report does not seek to assail farmers who raise cattle, pigs, chickens, etc. To the contrary, farm animals are vital parts of biodiverse, nutrient-cycling agro-ecosystems—core to regenerative agriculture, agroecology, mixed farming, and a range of solutions we would be wise to consider. That said, however, we must also acknowledge that emissions from current livestock production systems 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 if we are to reduce overall agricultural emissions in line with Canada's commitments and planetary limits.

E. The composition of fuel use emissions have changed significantly in the Atlantic provinces

Farm fuels in the Atlantic provinces emitted 0.21 Mt of CO_2e in 2021, slightly lower than the total of 0.29 Mt in 1990. 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 fossil-fuel-fired electricity-generating stations that supply some farms in the Atlantic provinces.

While the overall emissions from this category have changed relatively little, the components are quite different. During the 1990s, fuel oils were responsible for about three-quarters of emissions from on-farm fuel use, but they made up under a third of emissions in 2021. Conversely, emissions from diesel have risen from roughly a quarter of emissions from on-farm fuel use to nearly two-thirds in 2021.

F. Nitrogen fertilizer is an increasingly significant source of emissions

In 2021, total GHG emissions related to nitrogen fertilizer were 0.33 Mt CO_2e. 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) [6];
3d. Emissions from the carbon in some other nitrogen fertilizers (CO_2);
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).

As the tonnage of nitrogen fertilizer applied in the Atlantic provinces has increased (see Figure 3), emissions have also risen by almost 60% from 1990 to 2021. These emissions now make up over a fifth of total agricultural emissions from the Atlantic provinces. For further analysis of the important and problematic role of nitrogen fertilizer in agriculture, please read the NFU's 2022 report on that subject.[7]

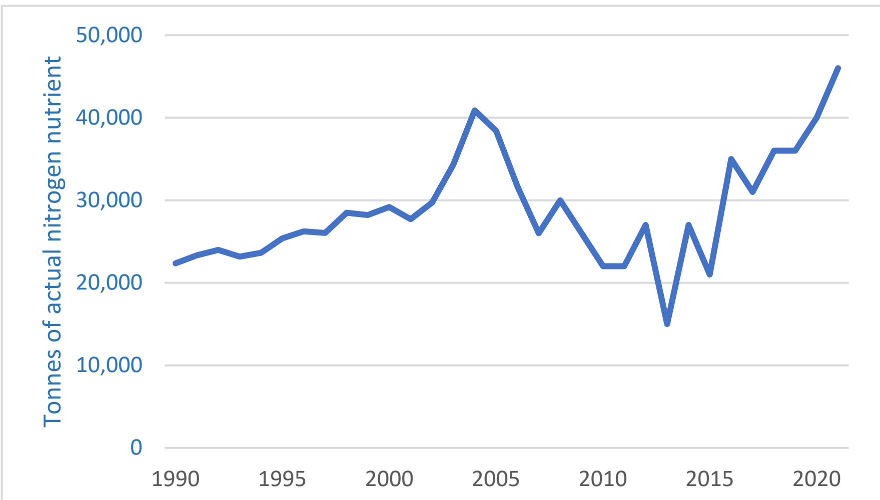

Figure 3. Atlantic provinces nitrogen fertilizer consumption, actual N nutrient, 1990–2021.
Sources: Statistics Canada Tables 32-10-0039-01 and 32-10-0274-01.

G. 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[8]:

- 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 0.23 Mt CO_2e per year or 14.5 percent of total agricultural emissions.[9] Moreover, much of this is CO_2 from fossil fuels. When we add these emissions to those from farm fuel and energy use (another 13.5 percent of total emissions), we begin to see that almost a third of agricultural emissions in the Atlantic provinces are directly related to

6 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 three categories together. As most of the emissions from these categories can be attributed to liming in the Atlantic provinces, the three categories are all attributed to 7a, recognizing that this understates emissions from urea and other carbon containing fertilizers.

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

8 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.

9 This is based on the sum of categories 3e, 3f, 3g, 4a, 4b, and 4c. Categories 3c and 3d are excluded.

fossil fuels and CO_2.[10] 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, 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 the Atlantic provinces' 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.

H. 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."

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 several points about the values in these tables:

A. In every year since 1990, agricultural soils in the Atlantic provinces have experienced net losses of carbon (i.e. desequestration).
B. Overall, desequestration—the transfer of carbon/CO_2 from soils to the atmosphere—currently appears to be increasing in the Atlantic provinces. Averaging the most recent five years for which data is available (2017–2021, inclusive) the six categories averaged +0.26 Mt per year, i.e., desequestration of that amount. But several years earlier (2010–2014, inclusive), those same six categories together averaged +0.23 Mt per year.
C. The most significant factor driving desequestration in the Atlantic provinces continues to be the creation of new farmland, mainly from forest. In 2021, land converted to cropland desequestered 0.20 Mt. The magnitude of soil carbon losses from this category have decreased from values of roughly 0.23 Mt in the early 2000s.
D. Desequestration from changes in the mix of annual versus perennial crops has been steadily increasing in the Atlantic provinces. Shifts that result in a larger area of annual crops and a

10 The total would be much more than half if CO2 from in-field hydrolysis of urea and UAN nitrogen fertilizer were included, and there are arguments for doing so because the C in that CO2 is derived from fossil fuels and added in fertilizer production facilities.

smaller area of perennials are reported as net transfers of carbon/CO_2 from soils to the atmosphere. In the table above, the overall balance of those changes in crop mix have resulted in desequestration ranging from +0.10 Mt in 1990 to +0.19 Mt in 2021.

E. Crop residue carbon input (which subsumes the now-discontinued category "Reduction in summerfallow area") is highly variable. For example, this category recorded -0.93 Mt of sequestration in 2018 but only -0.21 Mt in 2021, more than a fourfold change in just a few years.

F. Manure application is the most stable flow of carbon from the atmosphere to soils in the Atlantic provinces, though sequestration from this category has decreased from -0.43 Mt in 1990 to -0.30 Mt in 2021 with the shrinking cattle herd.

Atlantic Provinces LULUCF Sector Net GHG Flux Estimates, Selected Years

Sectoral Category		Net GHG Flux (kt CO2 eq)						
		1990	2005	2017	2018	2019	2020	2021
b.	**Cropland**	**225**	**270**	**329**	**286**	**330**	**363**	**380**
	Cropland Remaining Cropland	9.97	48.71	138	100	142	169	183
	Land Converted to Cropland	211	221	191	186	189	197	199
c.	**Grassland**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Grassland Remaining Grassland	NO	NO	NO	NO	NO	NO	NO
	Land Converted to Grassland	NO	NO	NO	NO	NO	NO	NO
d.	**Wetlands**	**350.2**	**681**	**827.9**	**624.9**	**699**	**745**	**816**
	Wetlands Remaining Wetlands	319.9	665.8	804	600.6	607.1	668.1	738.7
	Land Converted to Wetlands	34.49	19.49	28.94226	28.94226	96.94226	81.94226	72.94226

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

Categories	Land Management Change (LMC)	Emissions/Removals (kt CO_2)[a]						
		1990	2005	2017	2018	2019	2020	2021
Total Cropland Remaining Cropland		**9.97**	**48.71**	**138**	**100**	**142**	**169**	**183**
Cultivation of histosols		2.84	2.84	2.84	2.84	2.84	2.84	2.84
Perennial woody crops		-11.58	-15.07	-19.98	-21.47	-22.25	-24.14	-25.03
Total mineral soils		**19.72**	**61.4**	**155**	**119.5**	**161.8**	**191.2**	**204.6**
Change in crop mixture	Increase in perennial	-50.7	-109.2	-118.1	-117.2	-116.2	-115.2	-112.1
	Increase in annual	154.8	219.3	298.5	297.5	297.4	297.3	297.2
Change in tillage	Conventional to reduced	-1.3017	-3.1484	-3.503	-3.713	-3.892	-4.072	-4.252
	Conventional to no-till	-0.3662	-0.5884	-0.998	-1.218	-1.419	-1.549	-1.74
	Other[b]	-0.00478	0.1962	0.0659	0.1514	0.2208	0.296	0.412
Crop residual C input		-42.86	-52.29	-51.68	-93.36	-55.52	-30.8	-21.393
Manure application		-43.44	-38.8	-32.37	-31.84	-32.04	-31.59	-30.37
Land conversion—Residual emissions[c]		3.96	45.3	66	67.2	68.4	71.6	72.8

Notes:

a. Negative sign indicates removal 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

c. Net residual CO_2 emissions from the conversion of Forest Land and Grassland to Cropland that occurred more than 20 years prior to the inventory year, including emissions from the decay of woody biomass and DOM.

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.

Concluding remarks

While total agricultural emissions in the Atlantic provinces changed relatively little from 1990 to 2021, the composition of those emissions certainly shifted. Nitrogen fertilizer and diesel fuel are increasing sources of emissions, while livestock and fuel oil are less significant than they previously were. Agricultural soils are desequestering carbon at increasing rates, primarily due to land use changes.

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 agriculture.

The NFU hopes that this report and its data will help policymakers and farmers in the Atlantic provinces to tackle 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