Shifting Drivers and Trends in Territorial Reactive Nitrogen Emissions for Canadian Provinces Over Three Decades

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November 26, 2022

Abstract

Connecting the sources of reactive nitrogen (Nr) emissions to downstream environmental impacts is challenging, since Nr "cascades" through sequential ecosystems. It is therefore important to examine a jurisdiction's overall Nr emissions to gain perspective on whether total levels and specific forms of Nr emissions are being reduced. We study subnational (provincial) trends and variations in Nr emissions in Canada over 30 years (1990-2017) to examine the effects of key policy, socioeconomic, and technological changes on Nr emissions. We use data from national Nr emissions inventories, agricultural nutrient models, and wastewater treatment reports to estimate specific (N2O, NOx, NH3, and NO3), total (Gg N) and per capita (Kg N / capita) Nr emissions by province. We divide the initial sources of Nr emissions into 1) agricultural-related emissions, 2) fossil-fuel emissions, and 3) waste management emissions. Preliminary results show that annual total Nr emissions in Canada increased between 1990-2000 (1250 Gg to 1490 Gg), and have since decreased (to 1180 Gg). There was a redistribution of the main species of Nr, with decreases of NOx from fossil fuels (from 660 to 488 Gg Nr / year) and increases in agricultural Nr emissions (from 452 Gg to 537 Gg Nr / year). Provincial trends vary. Overall NOx emissions decreased across all provinces due to more stringent vehicle regulations, except in Alberta, where NOx emissions from export-oriented oil production increased. The increase in national agricultural emissions comes primarily from Saskatchewan whose combined agricultural emissions increased from 43 Gg to 97 Gg Nr year. Improving agricultural nitrogen-use efficiency, especially in these provinces, would be a key area for reducing Canada's Nr emissions. However, given that diesel and gasoline vehicles still contribute 121 Gg Nr / year, electrifying vehicle fleets would also have considerable potential for reducing Nr emissions. Our study demonstrates the variation in and reconfiguration of drivers of Nr emissions at the sub-national scale in Canada, emphasizing the need to consider local contexts and relative contributions of different economic sectors when examining national Nr emissions.

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Session: GC073 - Quantifying Nutrient Budgets for sustainable nutrient management

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Trends in territorial Nr emissions for Canadian provinces over three decades: Shifting drivers and economic sectors

Connecting the sources of reactive nitrogen (Nr) emissions to downstream environmental impacts is challenging since Nr "cascades" through sequential ecosystems. It is therefore important to examine a jurisdiction's overall Nr emissions to gain perspective on whether total levels and specific forms of Nr emissions are being reduced. We study subnational (provincial) trends and variations in Nr emissions in Canada over 30 years (1990-2019) to examine the effects of key policy, socioeconomic, and technological changes on Nr emission trends.

We use data from national Nr emissions inventories, agricultural nutrient models, and wastewater treatment reports to estimate specific (N_2O, NO_x, NH_3, and NO_3^-) and total Nr emissions by province (kg N $year^{-1}$). We divide the initial sources of Nr emissions into 1) agricultural-related emissions, subdivided into crop and animal production, 2) fossil-fuel emissions, divided into energy generation, transport, and industry and 3) wastewater emissions.

Preliminary results show that annual total Nr emissions in Canada have remained relatively constant between 1990-2019 (~1 Tg $year^{-1}$). However, there was a redistribution of the main species of Nr, with decreases of NO_x from fossil fuels from 660 to 487 Gg Nr $year^{-1}$ offset by increases in agricultural Nr emissions (N_2O, NH_3, and NO_3^-) from 345 Gg to 420 Gg Nr $year^{-1}$. Provincial trends vary. Overall NO_x emissions decreased across all provinces due to more stringent vehicle regulations, except in Alberta, where NO_x emissions from export-oriented oil production increased. The increase in national agricultural emissions comes primarily from two provinces, Saskatchewan and Manitoba, whose combined agricultural emissions increased from 83 Gg to 147 Gg Nr $year^{-1}$. Improving agricultural nitrogen-use efficiency, especially in these provinces, would be a key area for reducing Canada's Nr emissions. However, given that diesel and gasoline vehicles still contribute 129 Gg Nr $year^{-1}$, electrifying vehicle fleets also has considerable potential for reducing Nr emissions.

Our study demonstrates the variation in and reconfiguration of drivers of Nr emissions at the sub-national scale in Canada, emphasizing the need to consider local contexts and relative contributions of different economic sectors when examining national Nr emissions.

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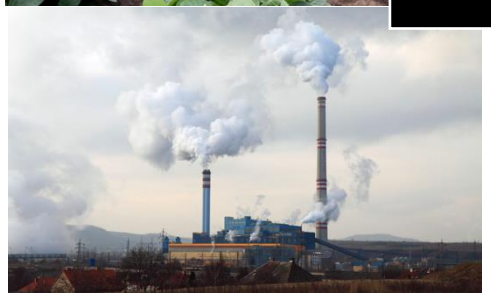
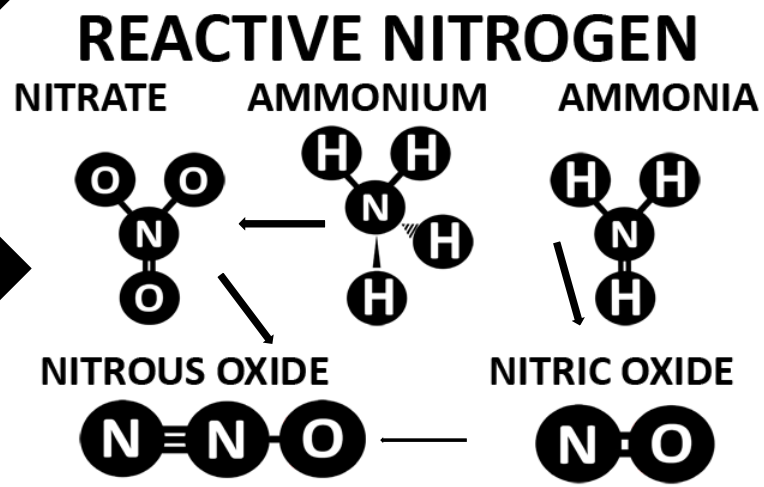
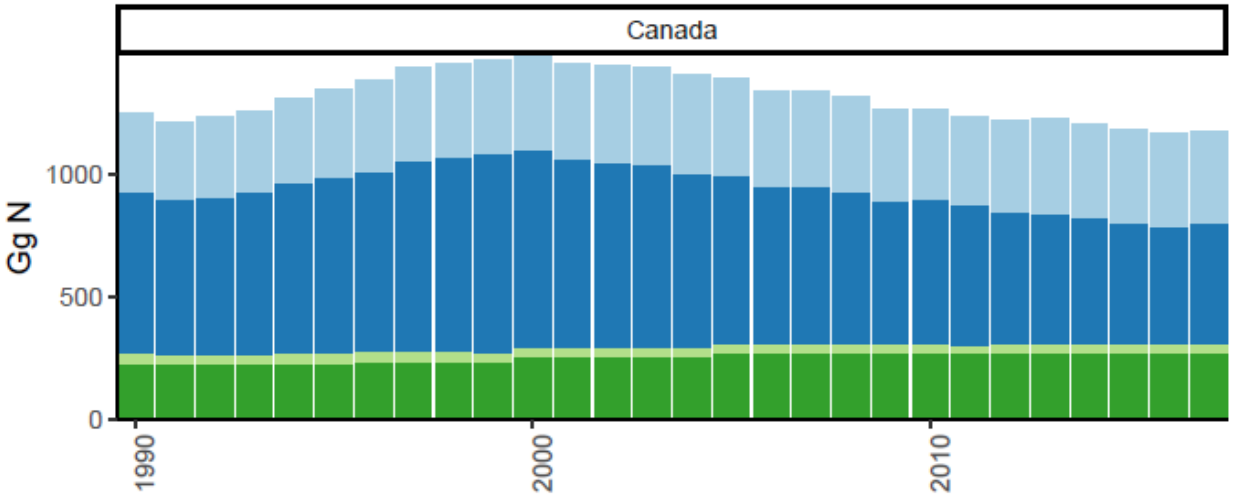
Important to assess multiple species of Nr simultaneously to understand overall national emission trends

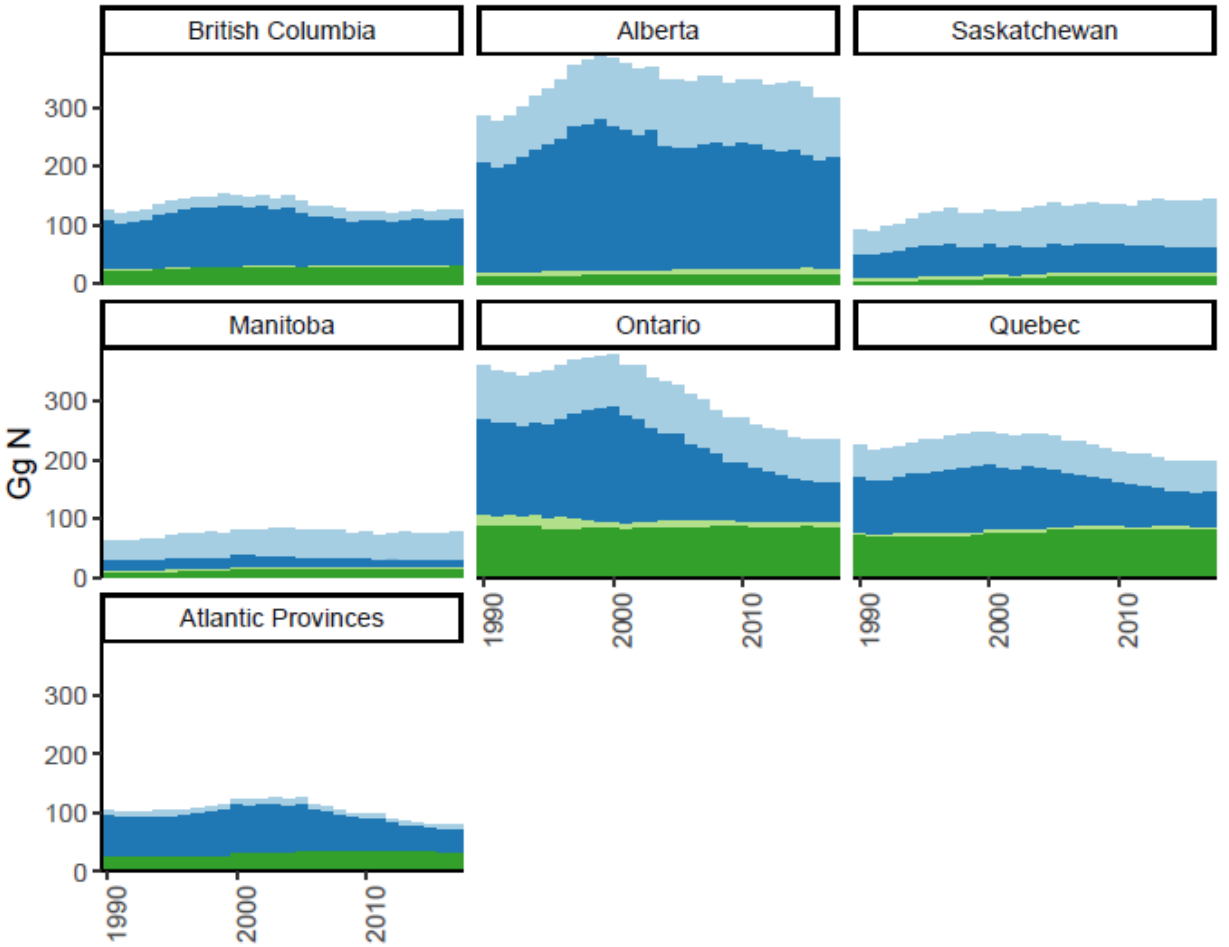




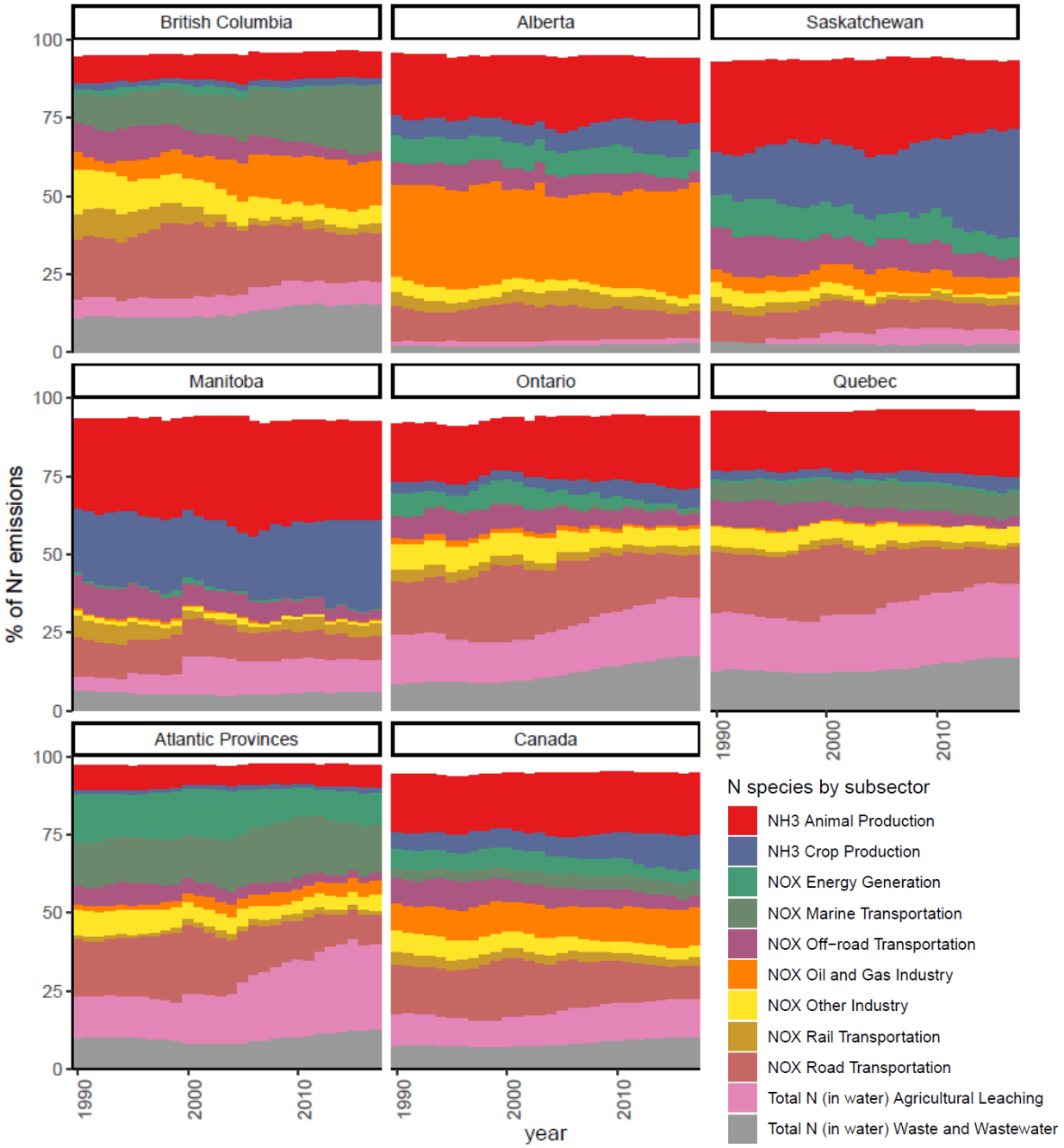
Nationally, main source of Nr changing from NO_x to NH_3



Heterogeneity in provincial total emissions, trends



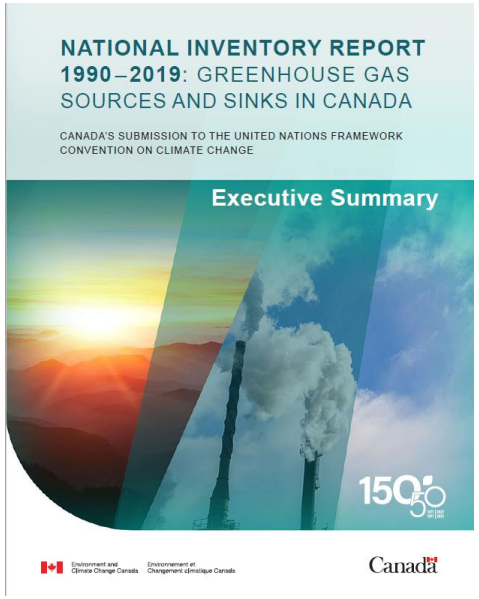
Primary sources of Nr emissions by province and year



Comprehensive subnational Nr accounting allows for assessment of “big picture” trends

Currently Canadian nitrogen policy is fragmented

Federal and provincial policies need to match geographic heterogeneity



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