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COMMENTARY

Forestry, Land-Use Change, and Canada's Carbon Trajectory: An IPAT/Kaya Decomposition

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Canada's commitment to its Paris Climate targets was confirmed on record by Prime Minister Mark Carney during the 2025 budget vote. Despite this the road toward meeting these targets remains in question (Curry & Levitz, 2025). While Canada's projections and public accounting of carbon dioxide (CO_2) emissions show reductions since the 2015 Paris Climate Summit, the Canadian government's publicly reported accounting omits Land Use, Land Use Change, and Forestry (LULUCF) (Environment and Climate Change Canada, 2025). In this analysis, I apply the IPAT/Kaya identity to CO_2 emissions decomposed into population (P), affluence (A: GDP per capita), and carbon intensity (T: CO_2/GDP) to examine the impact of including net fluxes from forest land and deforestation. Two series are compared: CO_2 emissions excluding LULUCF (includes fossil fuel and industrial sources) and CO_2 emissions including LULUCF (adding net fluxes from forest land and deforestation specifically). This comparison shows the influence land-use changes and forests have on our ability to mitigate climate change and highlights their significance in Canada's efforts to meet global climate commitments.

Globally, recent findings show that in 2023, terrestrial carbon sinks weakened to their lowest point since 2003, largely due to temperature anomalies, forest degradation, and increased fire frequency (Ke et al., 2024). This trend is only exacerbated by evidence that terrestrial carbon sinks are becoming less effective under increasing temperatures, resulting in more CO_2 remaining in the atmosphere; in 2024 alone, atmospheric CO_2 concentrations rose by a record 3.5 ppm (United Nations, 2025). Looking at Canadian forests specifically, the global trend is reinforced by the fact that industrial harvest, insect outbreaks, and wildfires have shifted managed forests from net sinks to net sources several times in recent years (Kurz et al., 2018). This is confirmed by the results of this IPAT analysis, which highlights how Canada's apparent decarbonization trajectory diverges depending on whether forestry and land-use changes are included.

From 2000 to 2014, fossil and industrial CO_2 emissions (excluding LULUCF) increased slightly, at approximately 0.48% per year, but this trajectory changes significantly when forest land and deforestation fluxes are included, as net CO_2 emissions rise by +1.26% per year. This difference occurs because the forest land sink, although still negative, weakened during the period. However, part of the slow growth in $C0_2$ emissions during this period is not due to policy initiatives but to the impact of the recession from 2008 to 2010, with 2010 reflecting the economy rebounding. When the great recession period is excluded, emissions increased by 1.13% per year excluding LUCUCF and by 2.35% per year with LULUCF. In 2000, Canada's forests absorbed more carbon, but by 2014 their capacity to do so had declined. As a result, even though overall CO_2 levels remain lower when forestry is included, the trend changes from a decrease to an increase, offsetting modest reductions from fossil fuel emissions.

In efficiency terms, carbon intensity excluding LULUCF fell sharply (−1.55% per year), but with forestry included, the decline slowed to −0.78% per year. From 2015–2022, the post-Paris period, fossil fuel CO_2 did not grow (−0.05% per year), possibly reflecting efficiency gains, policy interventions, and structural economic shifts. When including forestry fluxes, emissions also appear nearly flat (~0%/yr). However, removing the 2020 COVID-19 year and the 2021 rebound, emissions continued to increase with and without LULUCF at rates of 1.51% and 1.85% respectively. Intensities fell in both cases, but again more sharply excluding forestry (−1.93% per year vs −1.88% per year). Over the entire 2000–2022 period, fossil CO_2 fell at −0.82% per year, while net CO_2 rose at +0.84% per year once forestry was included.

Table 1: *Compound Annual Growth Rates (CAGR) for 2000–2014 (Pre-Paris Emissions targets), 2015–2022 (Post-Paris Emissions Targets), and 2000-2022 (Cumulative Period)*

Period	Period Excl. (%)	CO_2 Excl. (%)	CO_2 Incl. (%)	Populati on (%)	GDP per Cap (%)	Intensity Excl. (%)	Intensity Incl. (%)
2000–2014	+0.48	+1.26	+1.03	+1.01	−1.55	−0.78	+0.48
2000–2014 (Excl. 2008-2010)	+1.12	+2.35	+1.01	+1.50	−1.37	−0.17	+1.12
2015–2022	–0.05	≈0.00%	+1.25	+0.67	−1.93	−1.88	–0.05
2015–2022 **(Excl. 2020–2021)**	+1.51	+1.85	+1.15	+2.58	–1.04	–0.71	+1.51

Note. All data used in calculations were taken from the World Bank (2025). Population, total, (SP.POP.TOTL); GDP per capita (constant LCU); carbon dioxide (CO_2) emissions (total) excluding LULUCF. Total CO_2 emissions including LULUCF = carbon dioxide (CO_2) emissions (total) excluding LULUCF + carbon dioxide (CO_2) net fluxes from LULUCF (forest land) + carbon dioxide (CO_2) net fluxes from LULUCF (deforestation). Emissions are measured in Mt CO_2e.

As CO_2 accounted for 79% of Canada's GHG emissions in 2023, reducing these emissions is critical for achieving national climate targets (Environment and Climate Change Canada, 2025). The inclusion of forest land and deforestation fluxes reverses Canada's apparent progress, changing its CO_2 trajectory from negative to positive. This illustrates that forestry and land-use change fundamentally alter the country's climate narrative.

Recent extremes only further underscore the need for accurate accounting, as Canada's 2023 wildfires burned 7.8 million hectares, yet these fluxes remain excluded from official greenhouse gas reporting (Macarthy et al., 2024). To put this into perspective, this amounts to seven times the average annual burn area of the previous four decades, and emitted an estimated 647 Mt CO_2—an amount almost equal to India's total annual fossil fuel emissions in the same year (Wang et al., 2024; Byrne et al., 2024). These emissions were not included in the IPAT analysis, but their inclusion would only paint a more dire picture.

In Canada, the trend of weakening forest carbon sinks is significantly impacted by clear-cutting practices and a lack of integrated land-use planning that aligns forest management with multi-value objectives (Messier et al., 2016). Recent analysis by Polanyi et al. (2024) estimates logging-related emissions at 147 Mt in 2022, placing the sector as the third-largest emitting sector in the country. Studies have shown that increased harvest intensity (clearcuts being the most extreme) leads to higher carbon emissions, as well as declining biodiversity which further impacts the forest's capacity to sequester and store carbon (Simard et al., 2020). To mitigate this, forest management practices must evolve. Recent research supports this, and Cheng et al. (2024) argue that conserving and promoting functionally diverse forests (especially in resource-rich environments) can significantly improve both carbon and nitrogen sequestration. This is further reinforced by Griscom et al. (2017), who found that improved forest stewardship could potentially provide 37% of the carbon mitigation needed for stabilizing global warming below 2◦C by 2040.

The implications outlined here, and further supported by the IPAT analysis, confirm that Canada's climate progress, as measured against Paris Agreement targets, depends not only on reducing fossil fuel emissions but also on stabilizing the health and resilience of its forests. Evidence from Natural Resources Canada's 2024 report on Canadian forest carbon emissions supports the conclusion that without improved management and restoration, Canada's forests will remain net carbon sources for the foreseeable future. The Stern Review (2006) and OECD (2021) both emphasize that investing in forest conservation and restoration represents a highly cost-effective mitigation strategy relative to industrial decarbonization. Integrating nature-based solutions could therefore help Canada reduce total CO_2 at a lower marginal abatement cost while supporting biodiversity and forest resilience. Beyond this, adopting alternative harvesting methods that release less carbon and preserve biodiversity is necessary to mitigate carbon emissions while restorative actions are implemented (Messier et al. 2016). As forests are a vital component in Canada's effort to achieve it's 40% emission reduction by 2030, and net- zero by 2050 (Government of Canada 2025), it is imperative that forest management practices are reformed to reflect this reality.

Limitations

This identity decomposition does not establish causality but identifies patterns of association among population, economic growth, and emissions intensity. Differences between World Bank flux estimates and Canada's national inventory are expected due to variations in scope and methodology. As noted by Kurz et al. (2013, 2018) and the FAO (2020), disturbances such as wildfire, pine beetle infestation, and deforestation have significantly altered Canada's forest carbon dynamics. These events are not individually isolated here, but they illustrate the importance of prioritizing the health of Canadian forests and accurately recognizing forestry's role in national CO_2 mitigation. Future research could integrate time-series data from the Global Carbon Budget and NRC models to reconcile global and national carbon-accounting discrepancies.

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