Carbon for Soil Health and Climate Adaption

While it is vital to increase soil carbon as part of our climate change strategy, sequestration cannot be considered a substitute for reducing emissions.

Carbon sequestration

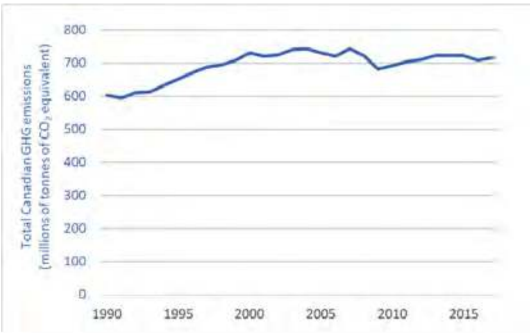
Soil carbon sequestration improves soil health. High-carbon soils are black, alive, rich-smelling, and full of beneficial fungi and other organisms. Higher soil carbon levels help crops withstand drought, reduce the need for energy-intensive irrigation, reduce the need for synthetic fertilizers which reduces greenhouse gas emissions, and perhaps even reduce the need for fungicides, herbicides, and insecticides.

We can sequester carbon in soils by enhancing grazing management and improving pastures; using different mixes of annual crops and rotations that include perennial crops, intercropping, or cover crops; reducing tillage in cropping systems; utilizing enhanced production systems or approaches such as agroecology, organic farming, and holistic management; and stopping the *de-sequestration* of carbon by protecting wetlands, shelterbelts, tree bluffs, and forests from destruction.

In spite of all the benefits of soil carbon sequestration, there is a risk of overstating its potential. The climate crisis cannot be solved by using soil to remove most or all excess carbon from atmosphere. This is not only impossible, but a dangerous idea when presented as a substitute for reducing emissions or a justification for continuing high-input, high-emissions practices.

Canada's annual GHG emissions from transportation, heavy industry, buildings and electricity, etc. are around 700 million tonnes CO_2 equivalent. Some of these GHGs, such as CO_2 stay in the atmosphere for hundreds of years. Thus, every year's emissions add to past emissions, increasing the atmosphere's total load of GHGs.

A 2016 Agriculture and Agri-Food Canada report states "it is projected that the annual rate of cropland soil carbon sequestration will decline from 11 million tonnes per year in 2013 to 6 Mt in 2030. *This is a result of the soil carbon sink approaching equilibrium* and limited scope for additional adoption of carbon sequestration practices such as no-till"



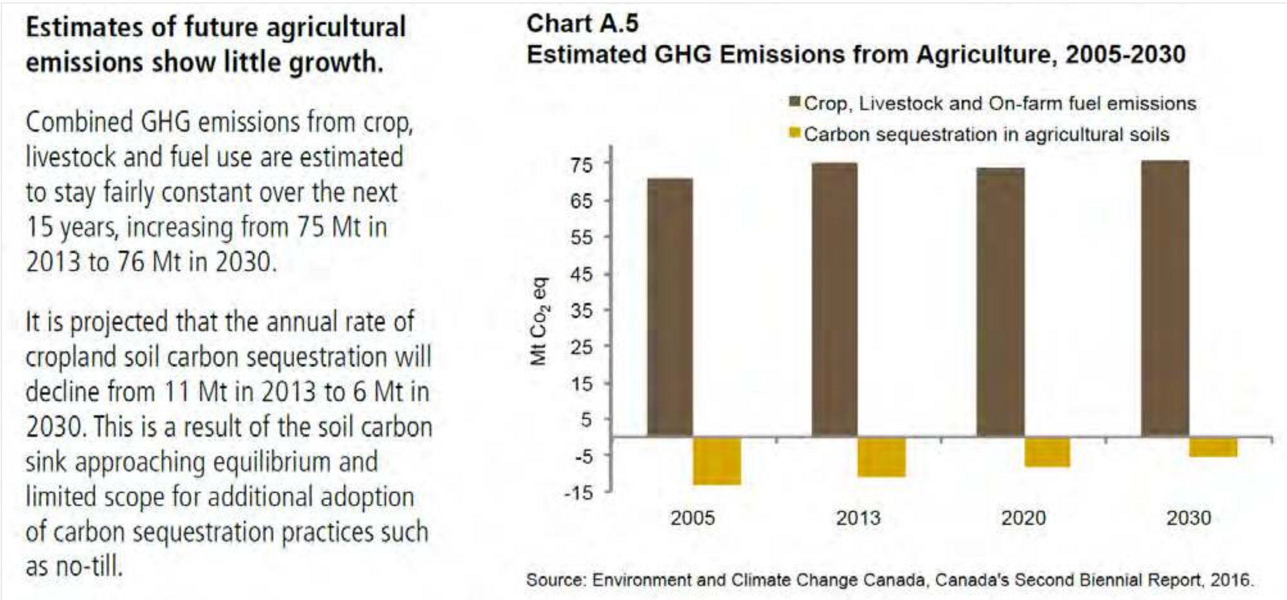
Total Canadian GHG emissions (CO_2, N_2O, and CH_4), 1990–2017 Source: Environment and Climate Change Canada, "Canada's Official Greenhouse Gas Inventory"

The soil's capacity to sequester carbon not only has limits, but soil carbon sequestration is tenuous and reversible. The rate of soil sequestration will decline over time as equilibrium is reached. Meanwhile, as emissions from agriculture and other sectors continue, they add to the atmosphere's GHG load, rapidly outrunning the soil's declining capacity to accept more carbon.

Emissions

Agricultural emissions make up about 12% of Canada's 80 million tonnes of annual greenhouse gas (GHG) emissions. Three main sources account for about 70% of total agricultural emissions:

- ⇒ fuel combustion and electricity from fossil fuels → about 11%;
- ⇒ nitrogen fertilizer production and soil emissions from fertilizer use → 29%; and
- ⇒ emissions from livestock → over 30%.



Canadian cropping system emissions and soil carbon sequestration, 2005–2030
Source: Agriculture and Agri-Food Canada, *An Overview of the Canadian Agriculture and Agri-Food System* (Ottawa: AAFC, 2016)

Limits and challenges

The amount of carbon a given soil can sequester in response to enhanced management is roughly equal to the amount previously released during sub-optimal management. Degraded soils can absorb lots of carbon, but well-managed and never-farmed soils can absorb very little. It is extremely hard to raise soil-carbon above pre-European settlement levels.

While high annual rates of sequestration are often presented as good news, how *fast* carbon is stored does not tell us *how much* carbon will ultimately be stored into those soils. Faster sequestration rates may simply lead to soils reaching equilibrium sooner. Soil carbon levels are in equilibrium when the speed at which carbon is added balances the speed at which soil microorganisms consume organic matter and release carbon as CO_2.

Changing from poorly managed grazing to enhanced grazing management will sequester carbon in the soil, whereas land that has been grazed rotationally for many decades has likely reached its equilibrium. It is the change to a new, positive practice, not the practice itself, which makes a difference.

Increasing soil carbon levels in the form of soil organic matter requires not just carbon but also nitrogen. Sometimes high carbon-sequestration rates are fuelled by adding supplementary nitrogen. Nitrogen fertilizer production and application both produce damaging GHG emissions, undoing the soil carbon benefits.

Soil-sequestered carbon can easily be released back into the atmosphere. Turning pasture into cropland, increasing tillage, or reinstating summer fallow can rapidly move carbon out of the soil, as can higher temperatures or lower rainfall (which are expected with climate change). Newly deposited soil carbon exists within a few inches or feet below the ground's surface, where it can be easily disturbed and enter the atmosphere again.

Measuring changes in soil carbon is difficult and expensive. There is no simple, inexpensive way to verify soil carbon gains and losses for all of Canada's farmland. And, for the most part, sequestration is not counted towards emissions-reduction targets. In assessing progress towards our Paris Agreement commitments, what matters are *increases* (if any) in the rate of soil carbon sequestration *over and above* the relatively high levels that existed in 2005.

Paradoxically, as we improve our soil stewardship practices, the rate of sequestration slows. Our potential to add more carbon to the soil decreases as we approach equilibrium, increasing the gap between total CO_2 emissions and carbon sequestered. Therefore, while it is vital to increase soil carbon levels as part of our climate change strategy, soil sequestration cannot offset ongoing emissions, and must not be considered a substitute for reducing emissions.