Data requirements to Model Carbon and GHG Emissions and Removals for Canada's GHG Inventory

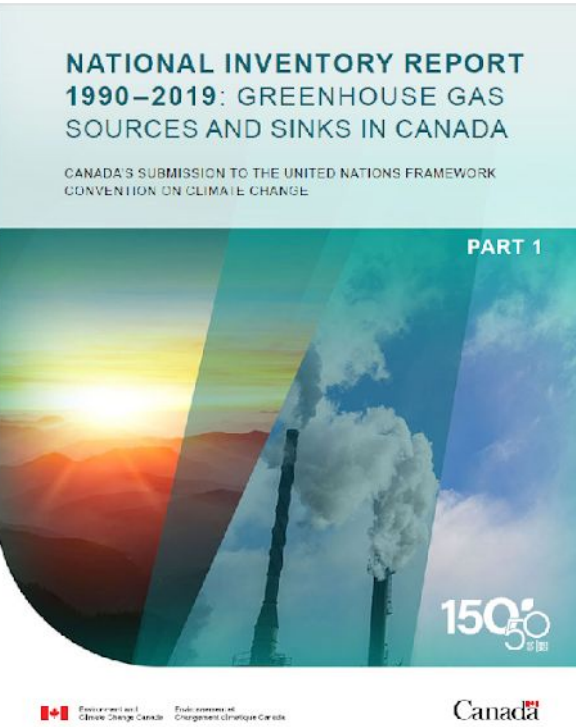
Dan MacDonald, Tim Martin, Darrel Cerkowniak,
Arumugam Thiagarajan, Xiaopeng Li

September 14, 2022

Outline

- National Inventory Reporting
  - Agricultural Greenhouse Gas Modeling
  - Cropland Carbon Modeling
- Data Needs

National GHG Inventory Reporting



- GHG Reporting- submitted annually as part of Canada's commitments under the United Nations Framework Convention on Climate Change (UNFCCC).

- The Intergovernmental Panel on Climate Change (IPCC) assesses the science related to climate change and provides guidance for generating national GHG inventories.

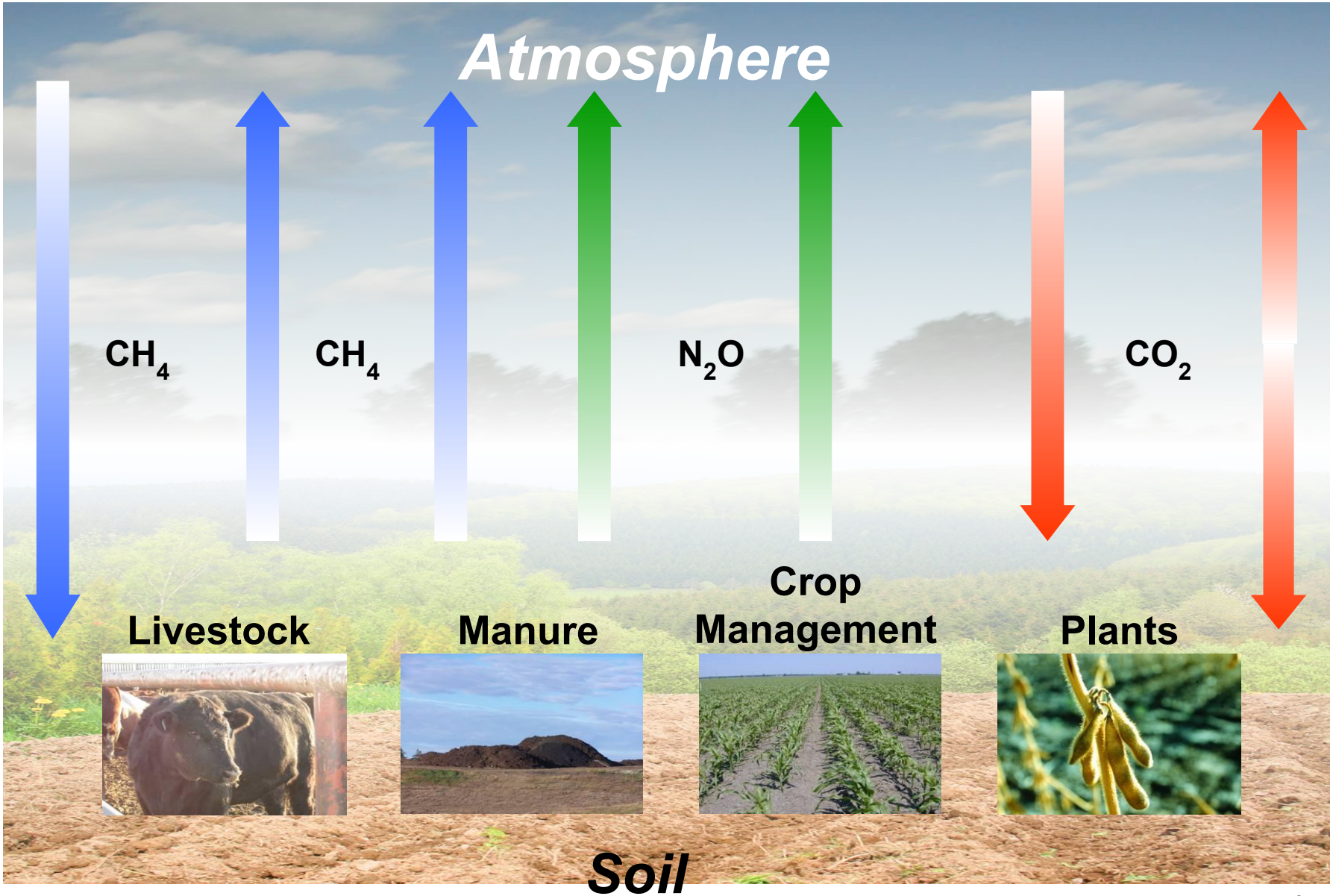
IPCC Reporting Sectors

- Energy (includes farm fuel use)
- Industrial Processes and Product Use
- Waste
- **Agriculture**
- **Land Use Land-Use Change and Forestry (LULUCF)**

CO_2 sources and sinks associated with changes in soil organic carbon or woody biomass on cropland and grassland are reported under the LULUCF Sector (IPCC)

Other agricultural Greenhouse gases (N_2O, CH_4) are reported under the Agriculture Sector (IPCC)

Agricultural Greenhouse Gas Modeling

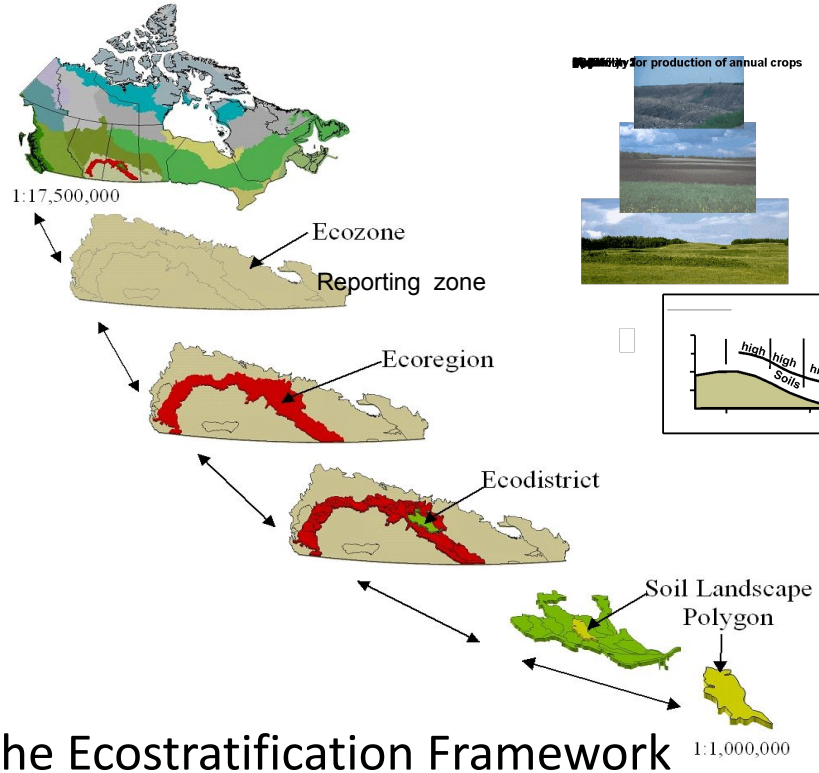


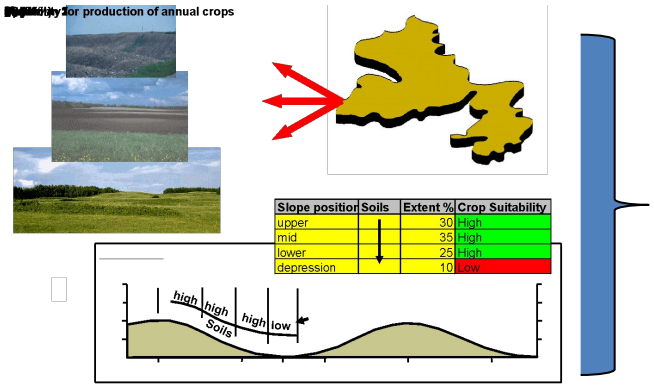
Carbon Modeling
- Current Practices

Spatial Framework

Soil Landscapes of Canada (SLC) Polygons serve as the primary Analysis unit

Ecostratification Framework





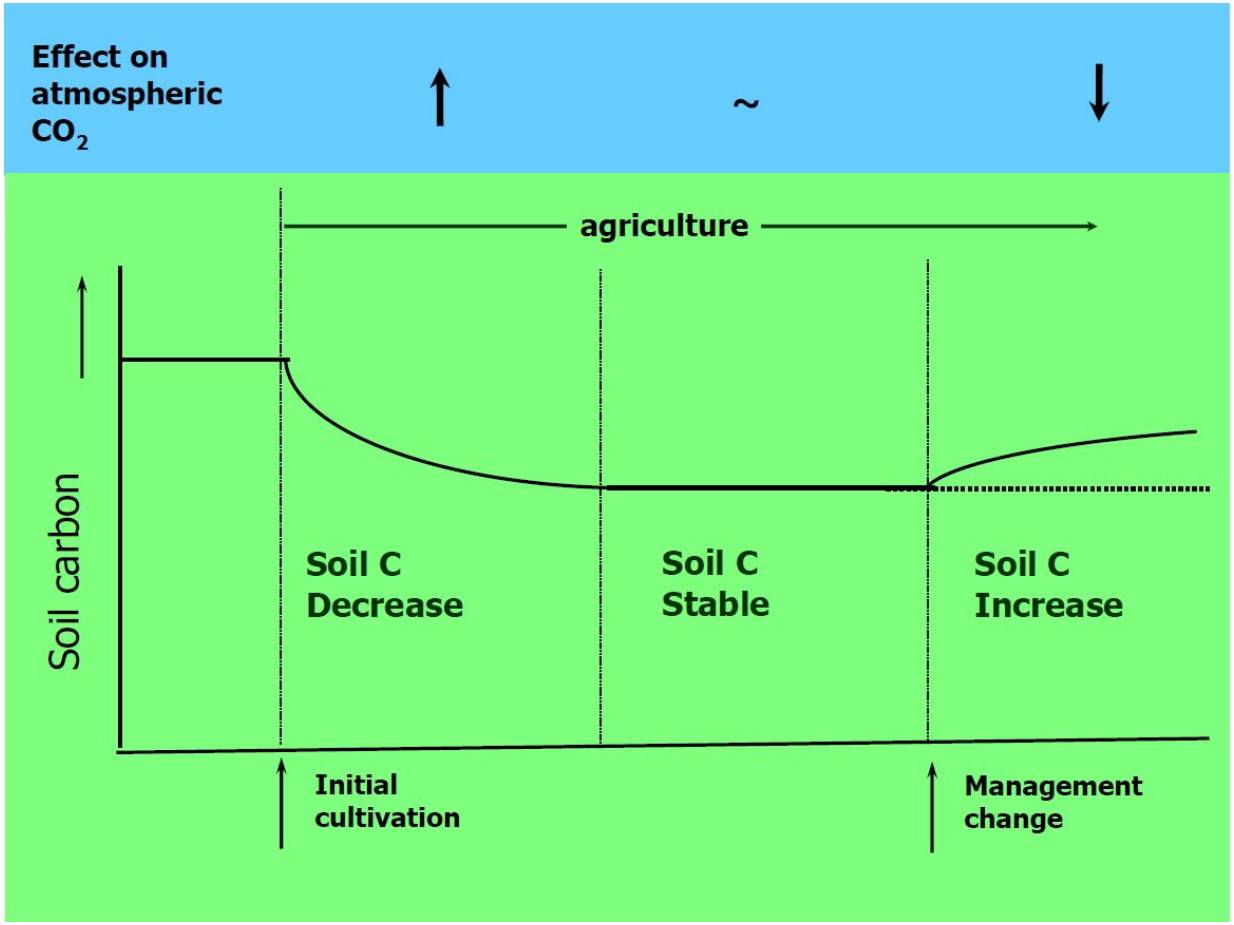
- There are 3487 polygons within Ag region,
- 5947 landscapes (1 to 4 landforms within each SLC
- 30,802 soil component/ landscape/slope segment records.
- Average SLC land area - 39,000 ha.

Soil Landscapes

The Ecostratification Framework allows for reporting at the regional provincial and national levels

Agricultural Region of Canada

Modeling the change in soil organic carbon (SOC) associated with changes in agriculture land management and land use.



Current carbon accounting methodology: Factor based approach

Carbon change coefficients are applied to net areas of change in land use and land management practices (LULMC) from one year to the next.

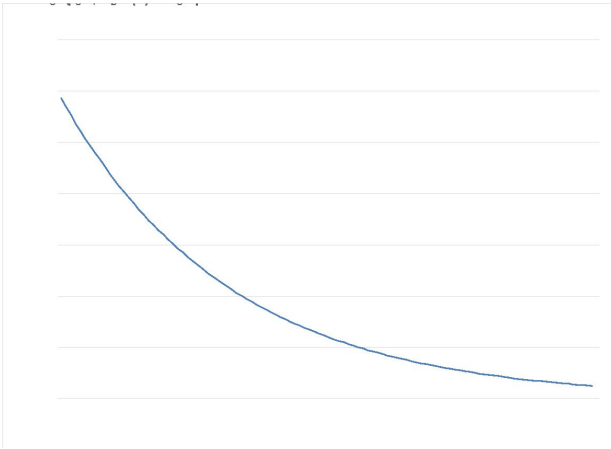
$\Delta C = F * A$

where:

ΔC= Change in soil C stock

A= Area of LULMC (ha)

F(y)= Average annual change in SOC subject to a LULMC



Generation of annual factor:

$$F(y) = \Delta C_{LMCmax} * [(\exp(-kval * (y-1)) - \exp(-kval * y)]/[y-(y-1)]$$

y= years since LMC

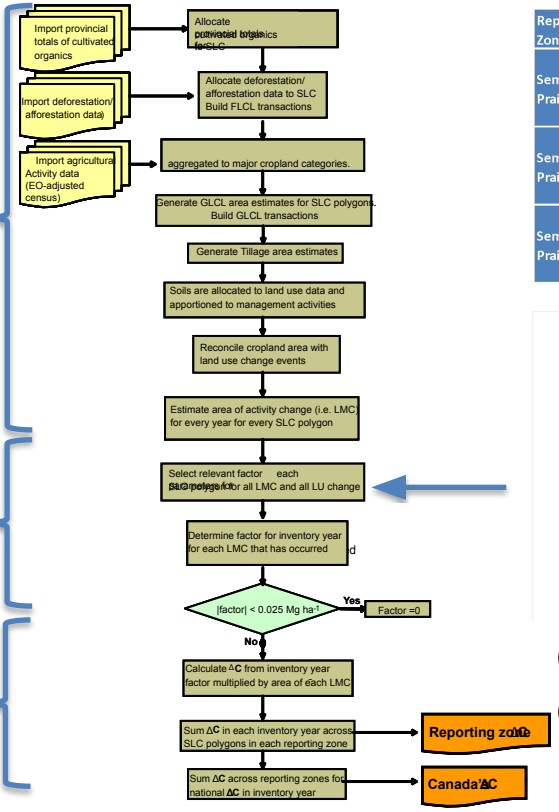
- KVAL - rate constant
- LUMCMAX - the maximum ΔC_{LMCmax} assumed to have been produced by the LMC

CANADIAN AGRICULTURAL GREENHOUSE GAS MONITORING ACCOUNTING AND REPORTING SYSTEM (CanAG-MARS)

Management of Activity data

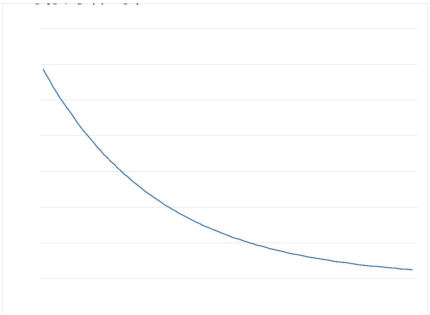
Generation of Emission /Removal Estimates

Inventory Reporting Tables



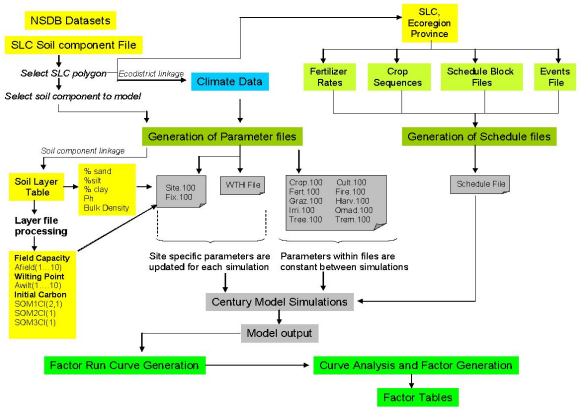
Factor Tables

Reporting Zone	RZ_NO	TEXCAT	FACTOR	KVAL	LUMCMAX (g/m2)
Semiarid Prairies	12	Coarse	Annual to Perennial	0.0336	1639
Semiarid Prairies	12	Medium	Annual to Perennial	0.0289	2519
Semiarid Prairies	12	Fine	Annual to Perennial	0.0218	3750

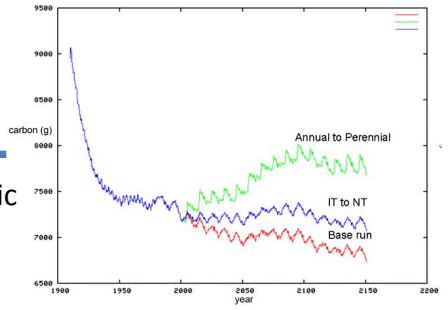


Carbon factors are time dependant.

Factors generated using CENTURY model runs or empirical studies



Factors specific to reporting zone, land management change and soil textural category

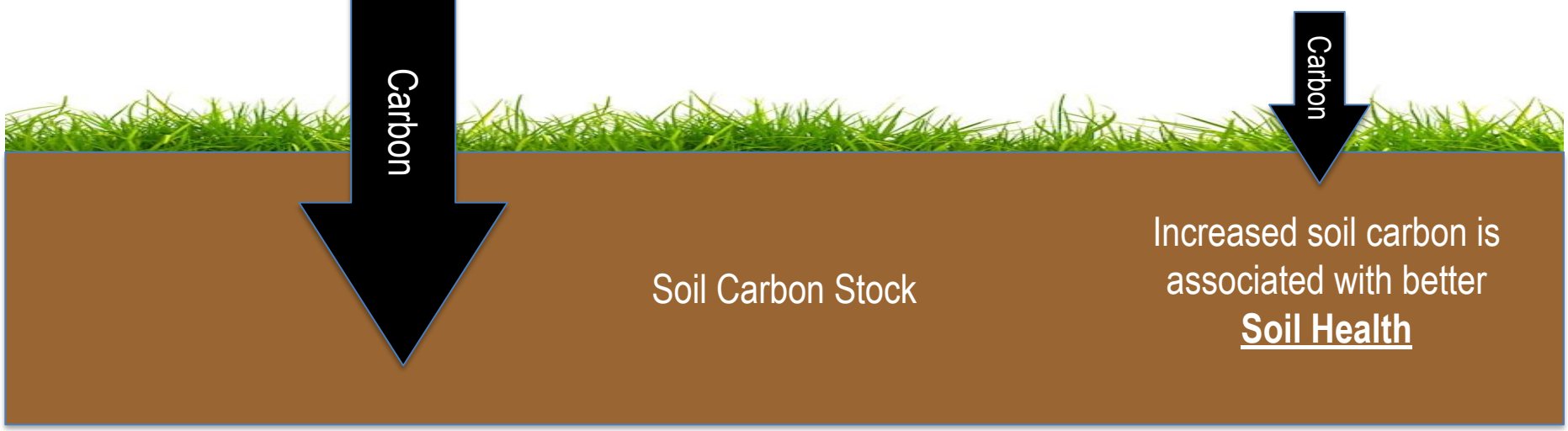


Current Factors Included in Canada's GHG Reporting to Sequester Carbon

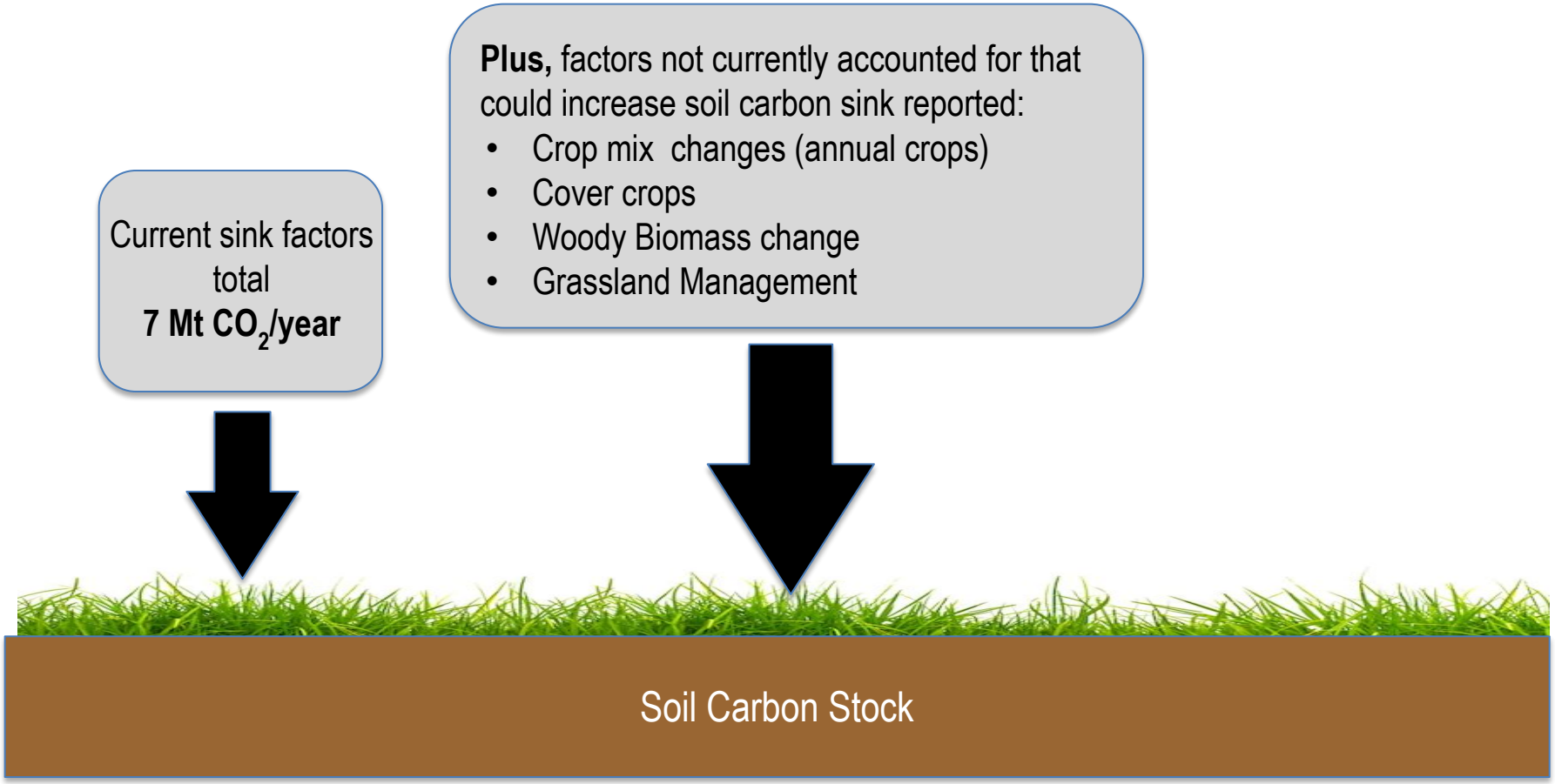
- Reducing tillage intensity. For example, switching from Conventional Till to **No-Till**
- **Annual Crop Productivity**
- **Manure Application**
- Switching from **annuals to perennials**
- Increased use of **perennial woody crops** (fruit trees, grapes, etc.)

(IPCC Tier 2 Carbon Change model)

As adoption of these practices continue, net carbon sequestration slows down and soils reach a new carbon balance.



Ongoing work to Include Factors Not Currently Included In Carbon Accounting



Considering these factors, reported soil carbon sequestration could be **increase significantly** by 2030.

AAFC is working with ECCC to better account for all factors affecting soil carbon. Many of these would increase the reported sequestration value.

METHODOLOGICAL IMPROVEMENTS
Agriculture and LULUCF/cropland

Now have updated methodology that considers changes in yield and corresponding changes in soil organic carbon resulting from increased N and manure application

Updates to N_2O emission factors in Agriculture

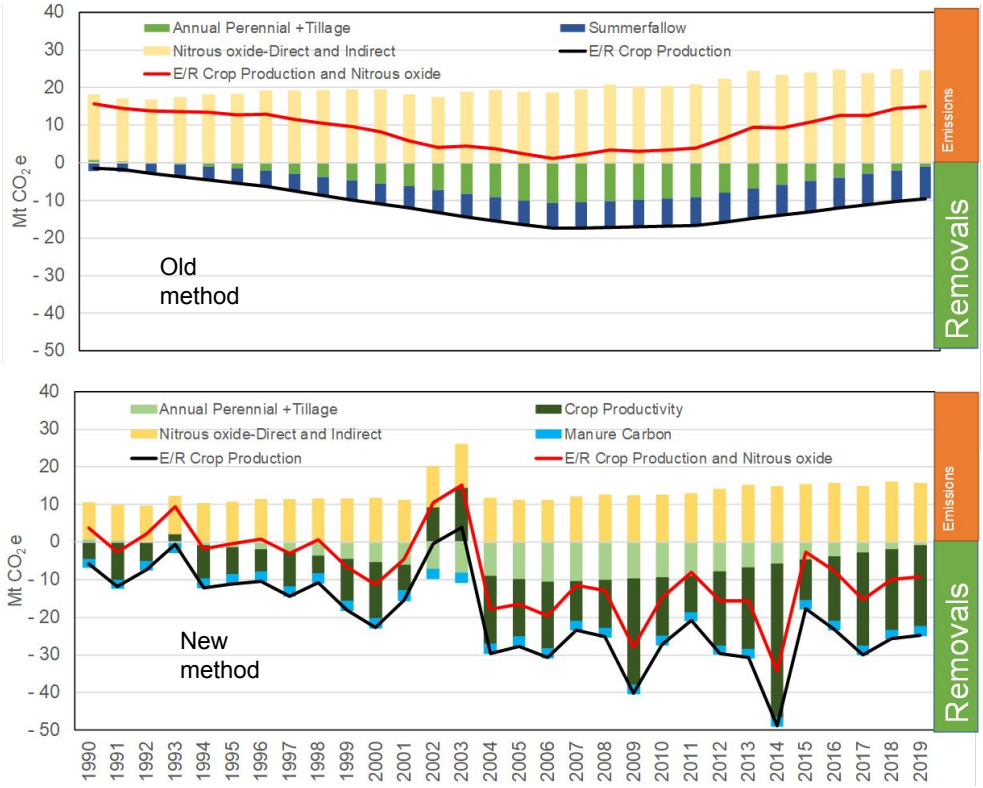
Meta-analysis recent data (Rochette et al. 2018), non-growing season emissions (Pelster). Cropland Carbon Model in LULUCF; Multi-model analysis against long-term crop production experimental results and Meta-analysis of long-term manure experiments (Liang and Thiagarajan)

Net downward revisions of GHG emissions

N_2O emissions revised down by 4-5 Mt CO_2 eq over the time series (included in national totals)

Removals of CO_2 were revised upwards by on average, 5 Mt CO_2 eq over the time series and on average, 10 Mt CO_2 eq post 2010

– Reported separately in LULUCF, not seen in national totals



Combined changes in fluxes of CO_2 from management of soil carbon in cropland and N_2O emissions from agricultural soil management. Upper panel: current method (published in NIR 2021); Lower panel: proposed modification.

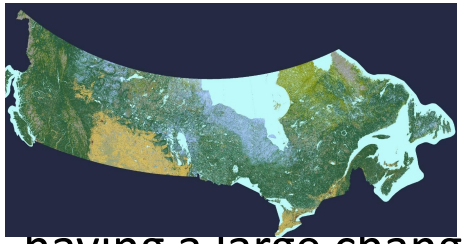
Carbon Modeling
- Data Needs

NIR Data: Considerations

Inclusion of land management activities for C modeling requires:

Activity data

- Availability of the activity data from at least 2005 onwards. Inventory reporting begins in 1990 so any data will have to be back-casted to 1990 or earlier.
- Availability of the activity data nationally or for the entire region in which the activity occurs (if the activity only occurs within a specific region of the country)



Model coefficients / Emission factors

- Significance of impact on C stocks. For example, having a large change in C per unit area of the activity, or having a large aerial extent of the activity, or both.
- Coefficients applicable for Canadian conditions.

NIR Data: Currently Used

The primary sources of activity data used to generate the GHG inventory include:

- **Crop, land management and livestock information**
  - Agricultural Census
  - Statistics Canada Farm Survey Data (Annual Field crop and Livestock Survey data, Farm Environmental Management survey (FEMS), Fertilizer Delivery Data
- **Soil and Landscape Information**

  -Soil and landscape data -> National Soils database (NSDB) SLC v3.2 .
- **Deforestation/afforestation estimates**

  -the Canadian Forest Service (CFS-NRCAN).
- **Land use Information**

  -AAFC Land Use maps and Crop Inventory Mapping
- **Climate data**

NIR Data Needs: BMP

Consideration of BMP's

Cover crops

- Not currently in the inventory
- Lack emission factors applicable for Canadian Conditions
- Rough estimates of activity in FEMS but lacks consistency between surveys. Resolution is coarse.

Woody Biomass (Tree planting, Shelter belts)

- Rough estimates of woody biomass on cropland in the inventory
- To adequately capture the impact will require improvements to activity data (species type, planting density, monitoring of gains and losses etc.)

Application of other organic amendments (municipal wastes, composts etc.)

- Not currently in the inventory
- Is there activity data, applicable coefficients?

Summary

- The models are continuously improved as new science and data emerge.
- Opportunities exist for additional improvements for several BMPs
  - Emission factors / modeling coefficients
  - Reliable and statistically-robust time series activity data by region

THANK YOU!

Overview

Management Activities

Cropland Management

- Changes in crop mixture (annual/perennial crop conversions)
- Changes in tillage practices: (intensive till, reduced till, no-till
- Cultivated organic Soils
- Changes in land under perennial woody vegetation (Christmas Trees, Orchards, Vineyards
- Impact of Crop productivity on annual cropland
- Application of livestock manure to annual cropland

- **Land Use Change**
- Forest land converted to cropland
- Grassland converted to cropland

Grassland Management