Agriculture and Agri-Food Canada   Agriculture et Agroalimentaire Canada

Experience using 2006 GL AFOLU methods for estimating mitigation potential for agriculture and carbon footprint of primary agricultural products.

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July 2014

Canada

Outline

- Background
- Analysis of Mitigation Potential for Agriculture
- C Footprinting for Primary Agricultural Commodities

Background

- Emissions from agriculture are dominated by emissions of N_2O for N applied to soil and of CH_4 from enteric fermentation
  - ❖ Key source categories so Canada has predominantly Tier 2 methods
  - ❖ Quantification is not simple so national inventory methods provide a highly acceptable source of methods
- Soil C stock changes are important
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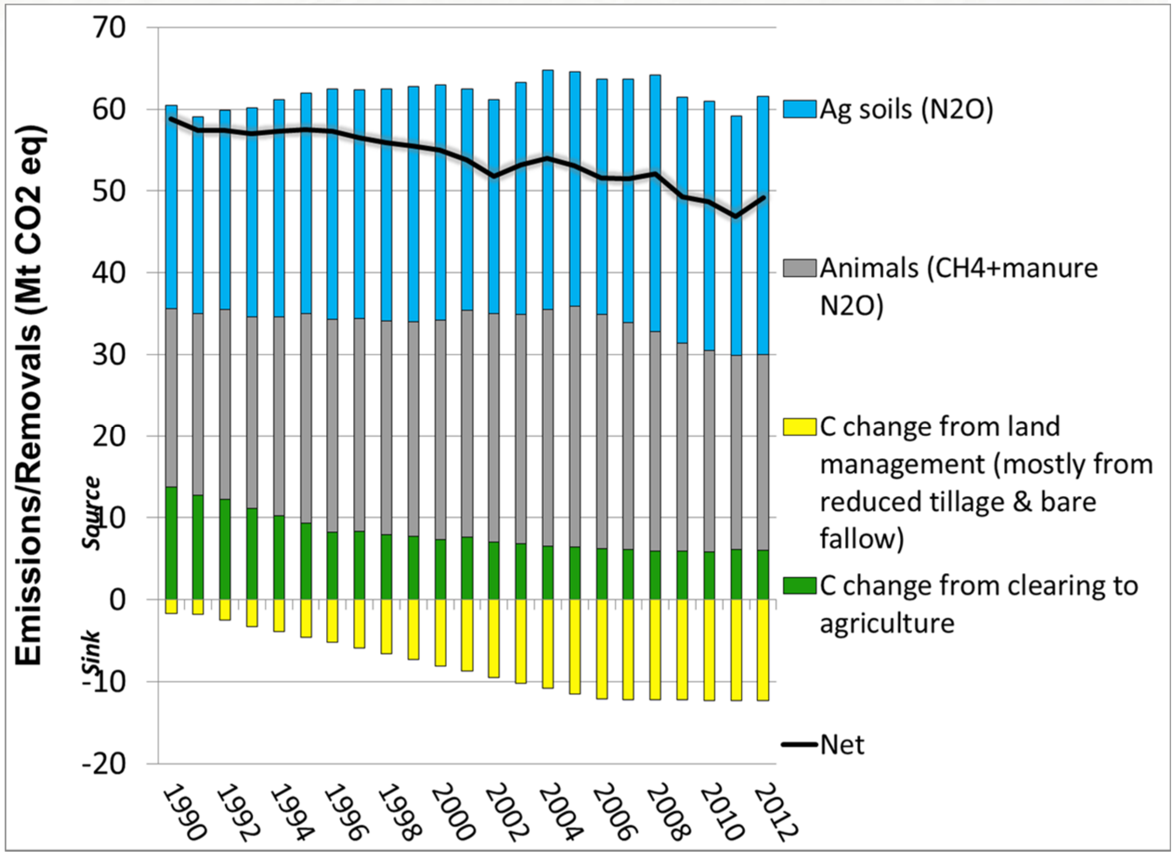
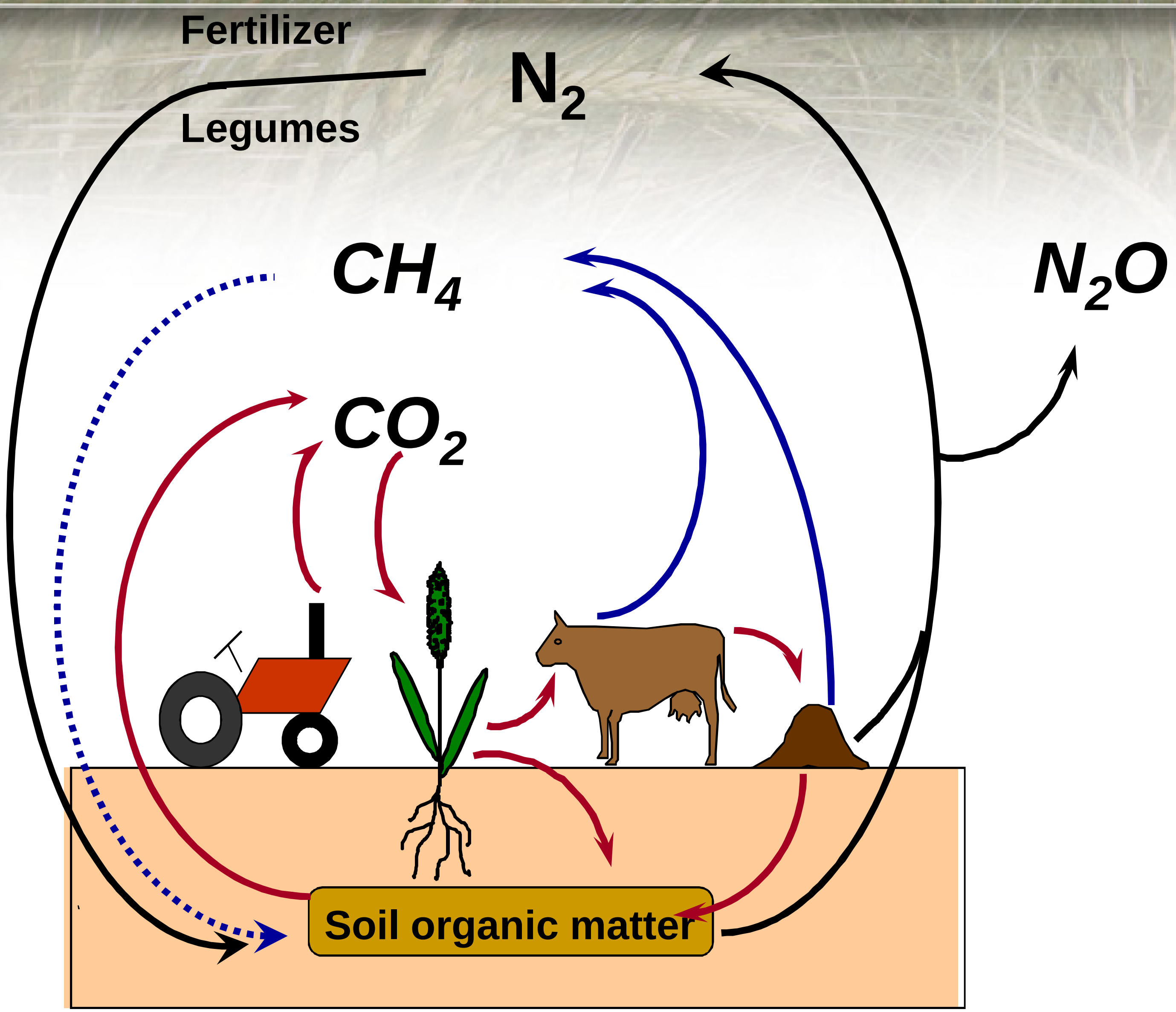


Emissions and removals from altering C and N cycles



Mitigation Potential

- Important that mitigation analysis are consistent with emissions and removals as estimated in the National Inventory
- Future “what if” scenarios of policy and prices
- AFOLU not fully adequate for policy purposes
  - ❖ Desire to capture all major emissions from agriculture
  - ❖ So include the emissions from on-farm fossil fuel use and for transportation of agricultural products from the farm to processor or export position
    - Reported within Transportation sector
    - Could be as high as 15% of total emissions depending on primary agricultural product
  - ❖ So include emissions embodied in direct inputs to primary agriculture
    - Nitrogen fertilizer the most important and could be up to 20% of total emission depending on primary agricultural product
- Using the national inventory system directly was not viable option due to the detail of agricultural activity data required

May need to include potential future activities not yet in inventory

- Existing 2006 GL-based inventory does not necessarily capture future mitigation options
  - ❖ For example, biogas production from manure not included in the inventory because not large activity
  - ❖ Not fault of 2006 GL, just lack of emission factors and accessible activity data in Canada

Metamodels Needed

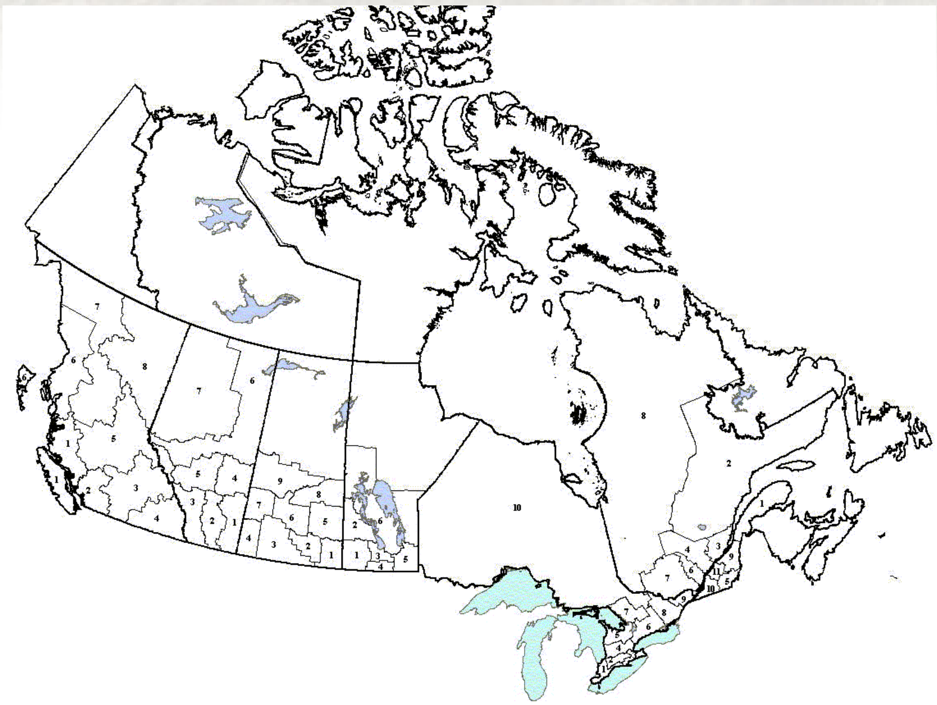
- Inventory has too much detail!
  - ❖ Use existing economic input-output models for agriculture
  - ❖ Activity data from future scenarios is less dense than actual activity data
- Soil C has legacy effects
  - ❖ Current or future C stock change affected by past changes of land use and/or land management
  - ❖ Approach used was to use the inventory system to derive a metamodel of C change
    - expected average in year of future scenario for activities
    - marginal C stock changes due to change in activity in future
  - ❖ These C change factors than used to estimate the effect on C change of the future scenario

Used an integrated modeling framework to estimate GHG emissions from agriculture

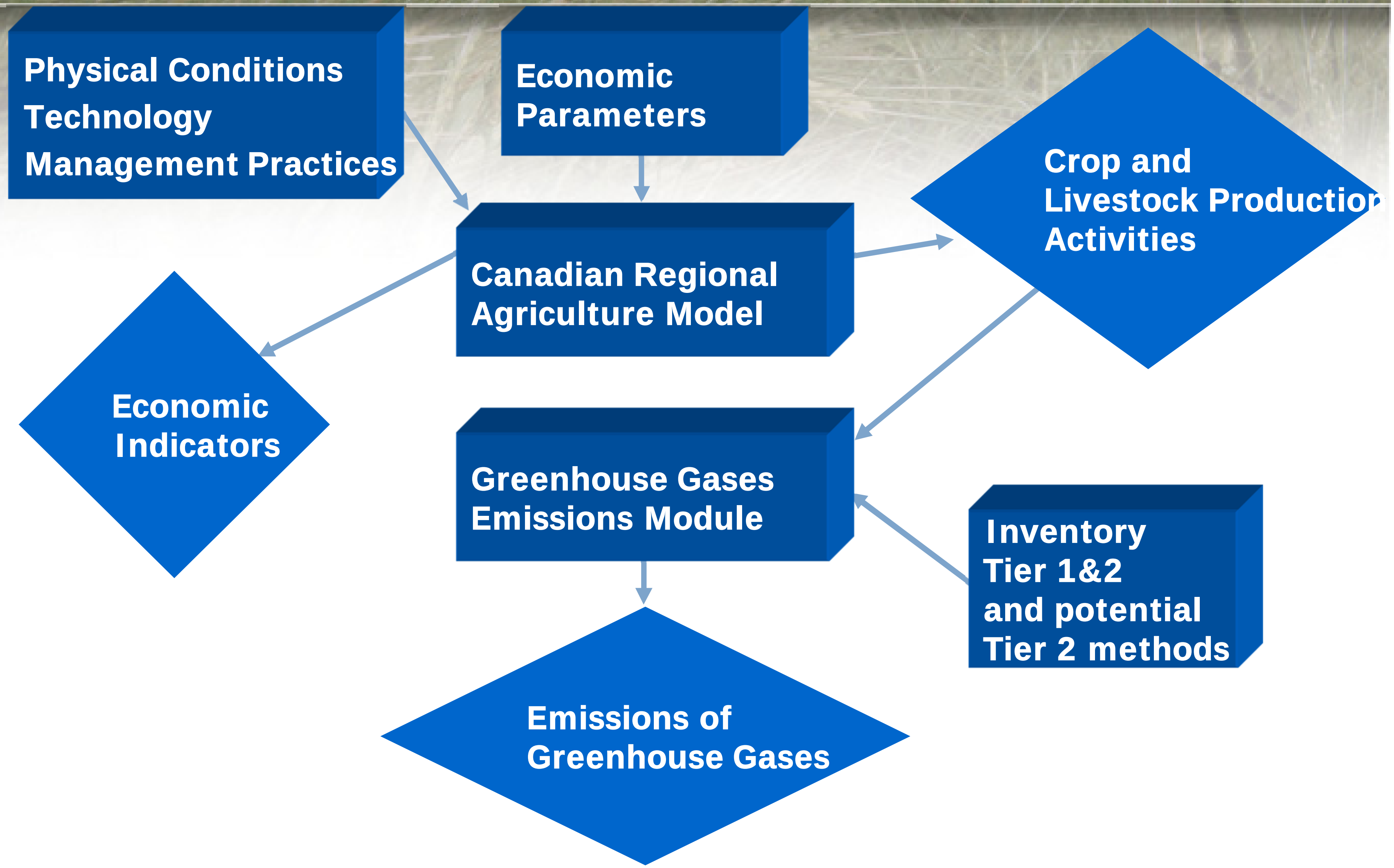
- The two components of the modeling framework are the Canadian Regional Agricultural Model and the GHG Emissions Module
  - ❖ The Canadian Regional Agricultural Model (CRAM) is an economic model that provides information on how activity levels in the agricultural sector respond to a wide variety of shocks
  - ❖ The GHG Emissions Module (GHGEM) is a spreadsheet metamodel of the relevant portions of the national inventory which uses the activity levels that CRAM estimates and emissions coefficients based on the national GHG inventory to calculate changes in GHG emissions from the agriculture
    - Emissions estimated by GHGEM in base year within 1% of those reported in national GHG inventory
- When combining these two models, this provides a tool that allows us to estimate changes in GHG emissions from agriculture in response to policy

Overview of the Canadian Regional Agricultural Model

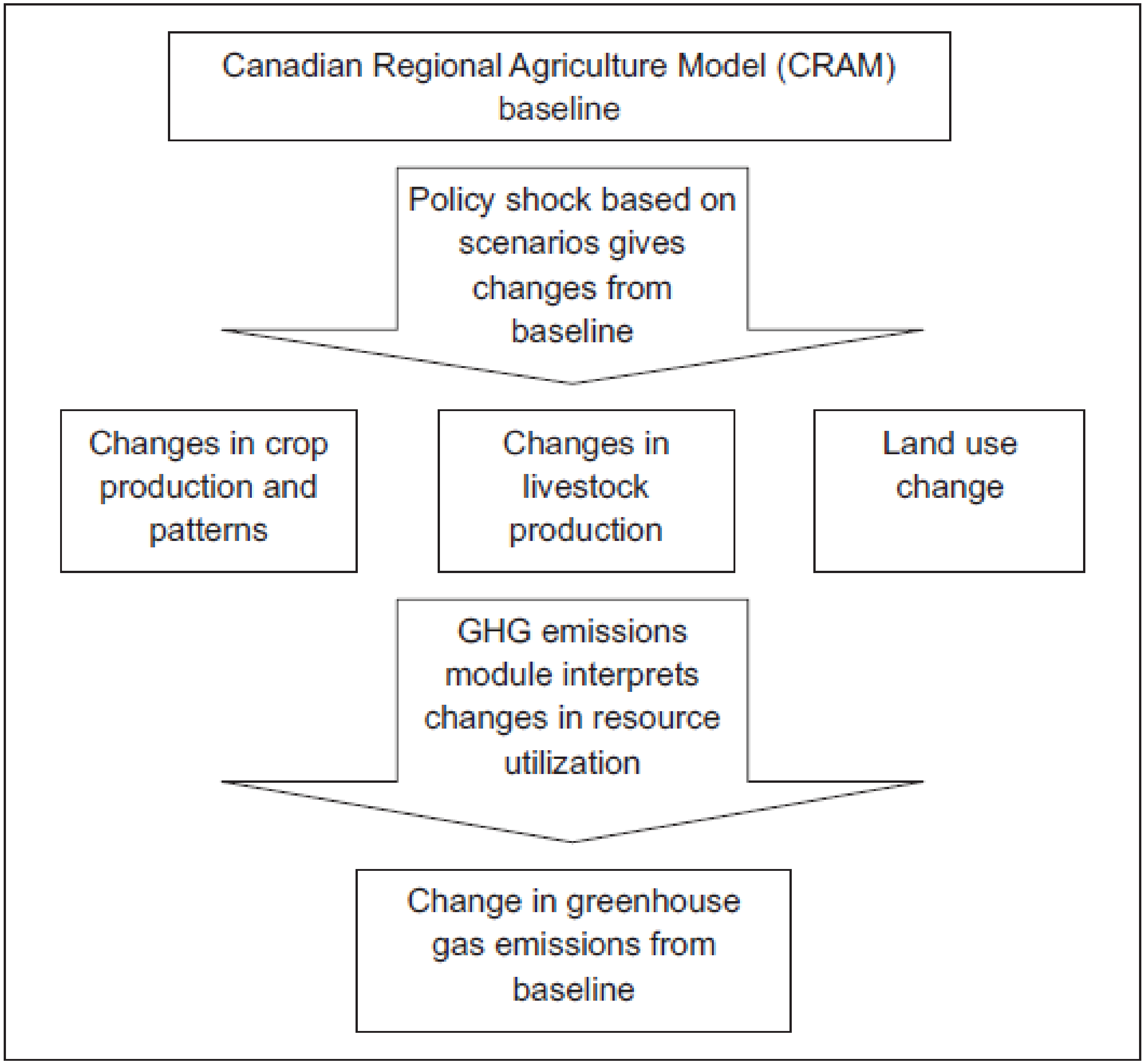
- CRAM is a static partial equilibrium model of the Canadian Agriculture sector, covering all of primary production (crops and livestock) and some processing activities
  - ❖ CRAM maximizes consumer and producer surplus
  - ❖ The only true constraint in CRAM is the availability of land for agricultural production
- CRAM is divided into 55 regions and can provide a very detailed regional breakdown of resource utilization in the agriculture sector
- CRAM does not provide a forecast but gives a before (baseline) and after (policy scenario) picture of the agriculture sector
- Various values of 1 tonne CO_2 eq mitigated is input to derive mitigation cost curves



Structure of CEEMA

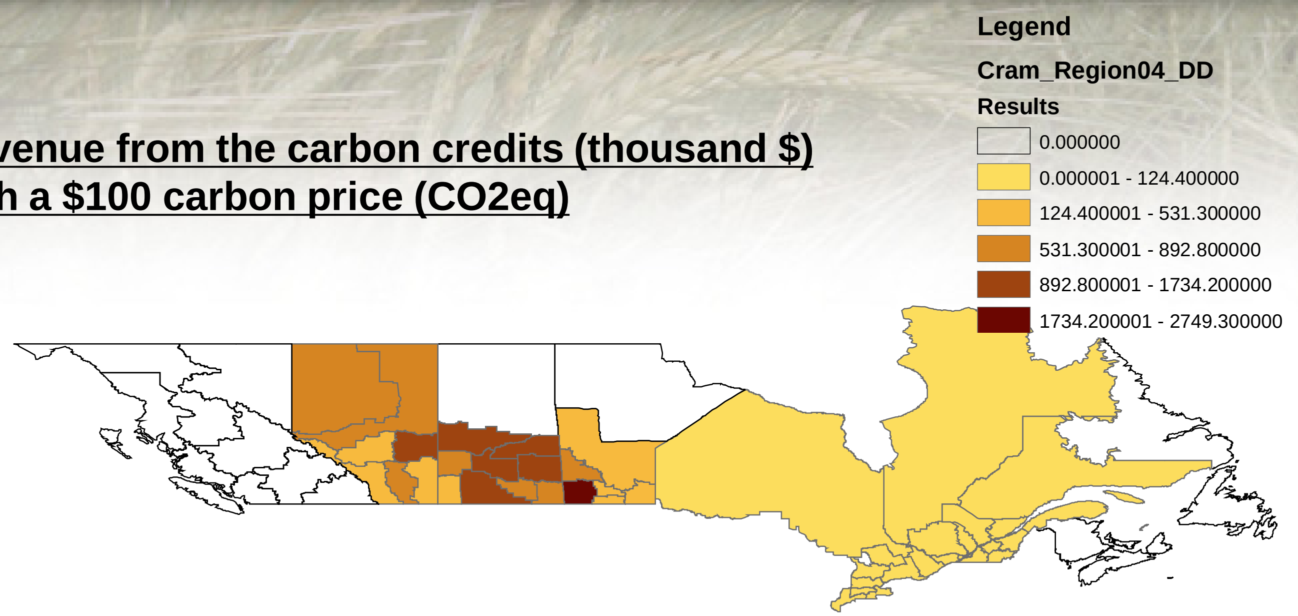


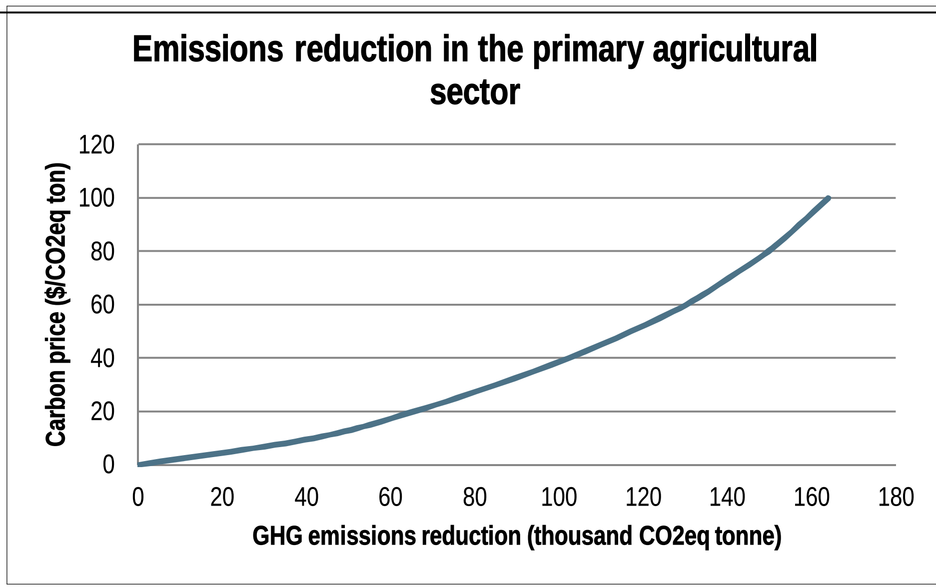
The following diagram provides an overview of the method



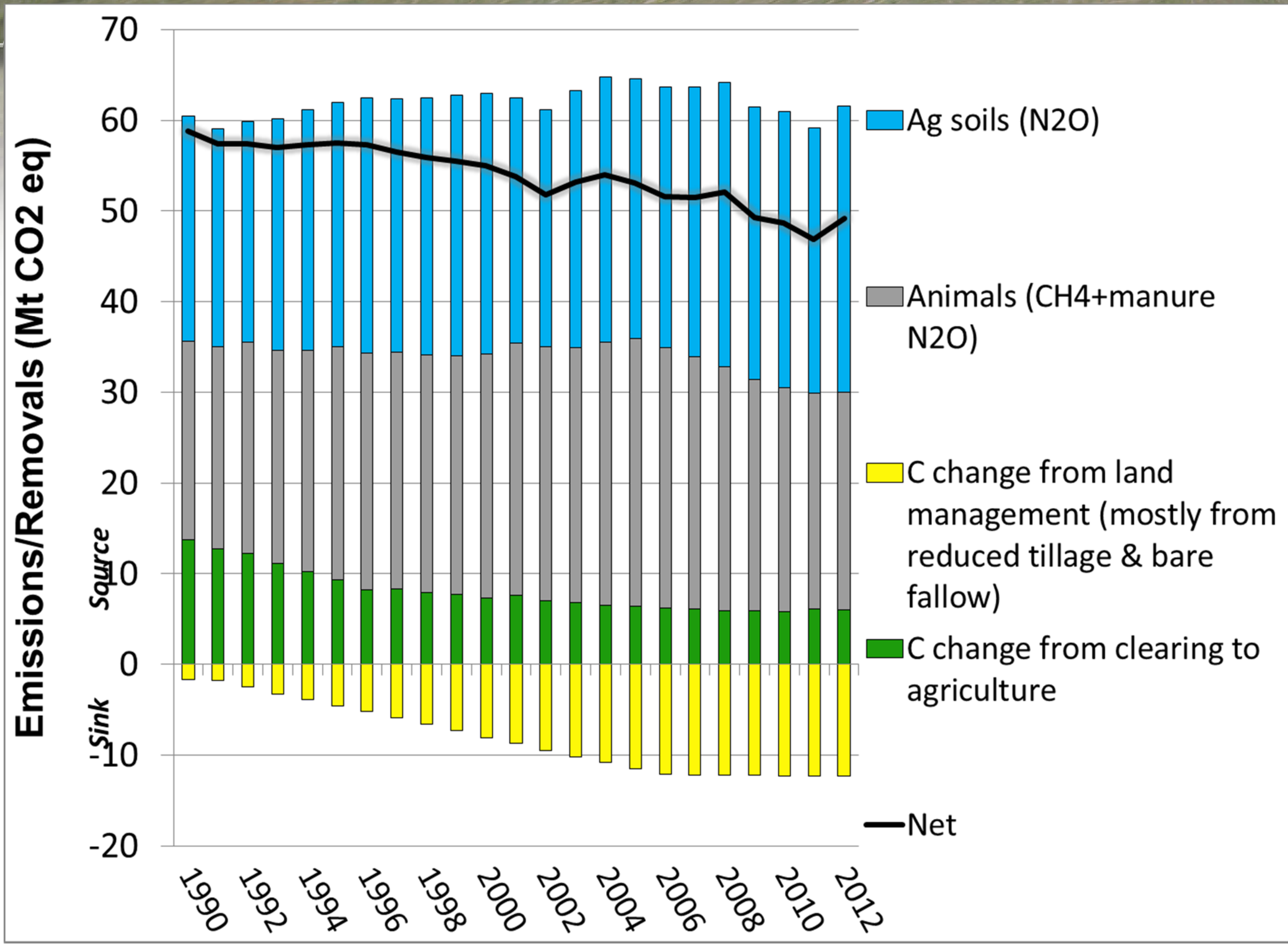
The economic potential for agriculture in Canada is limited

Revenue from the carbon credits (thousand $) with a $100 carbon price (CO2eq)



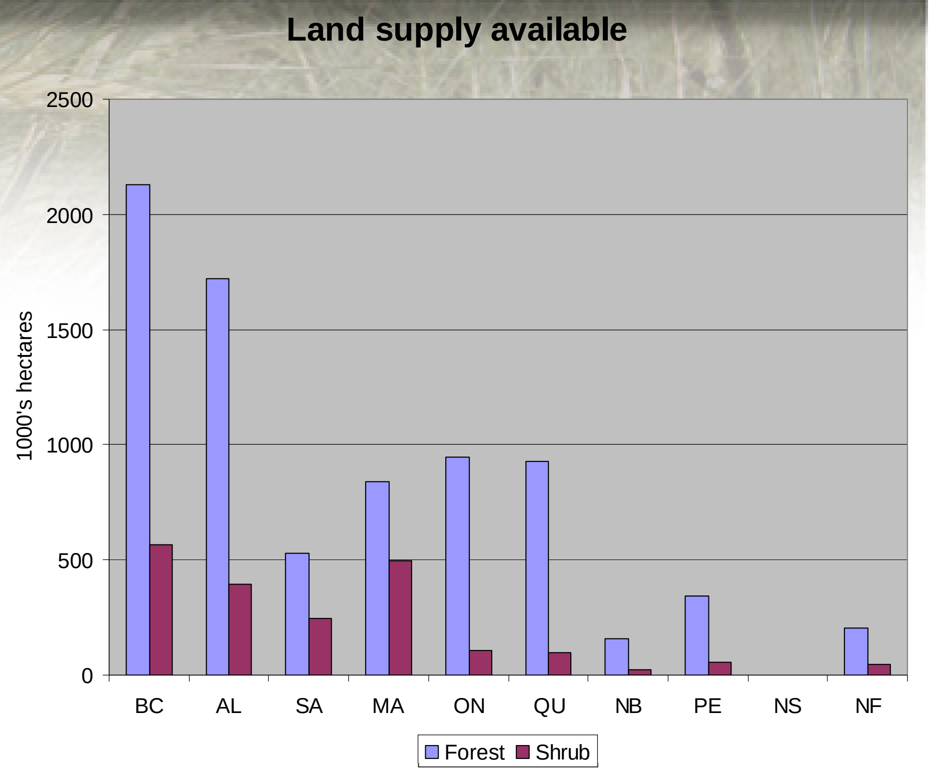


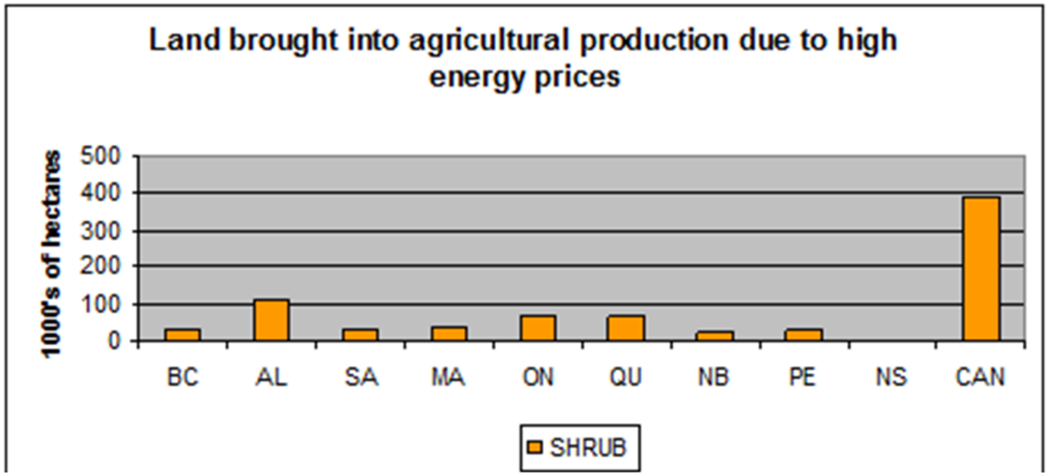
AFOLU GHG situation for agriculture



MITIGATION - Land Use Change modeling

- In order to assess the potential for land use change the supply of land suitable for agriculture that is not already in production had to be estimated
- To achieve this, the land in with good potential for agriculture was identified
- Amount of new land brought into production is relatively small compared with potential





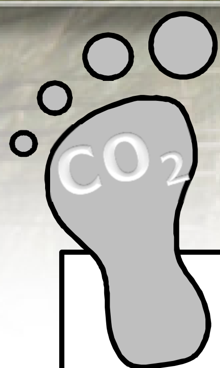
Source: Liu et al. 2014

Application of 2006 GL for C Footprint Analysis

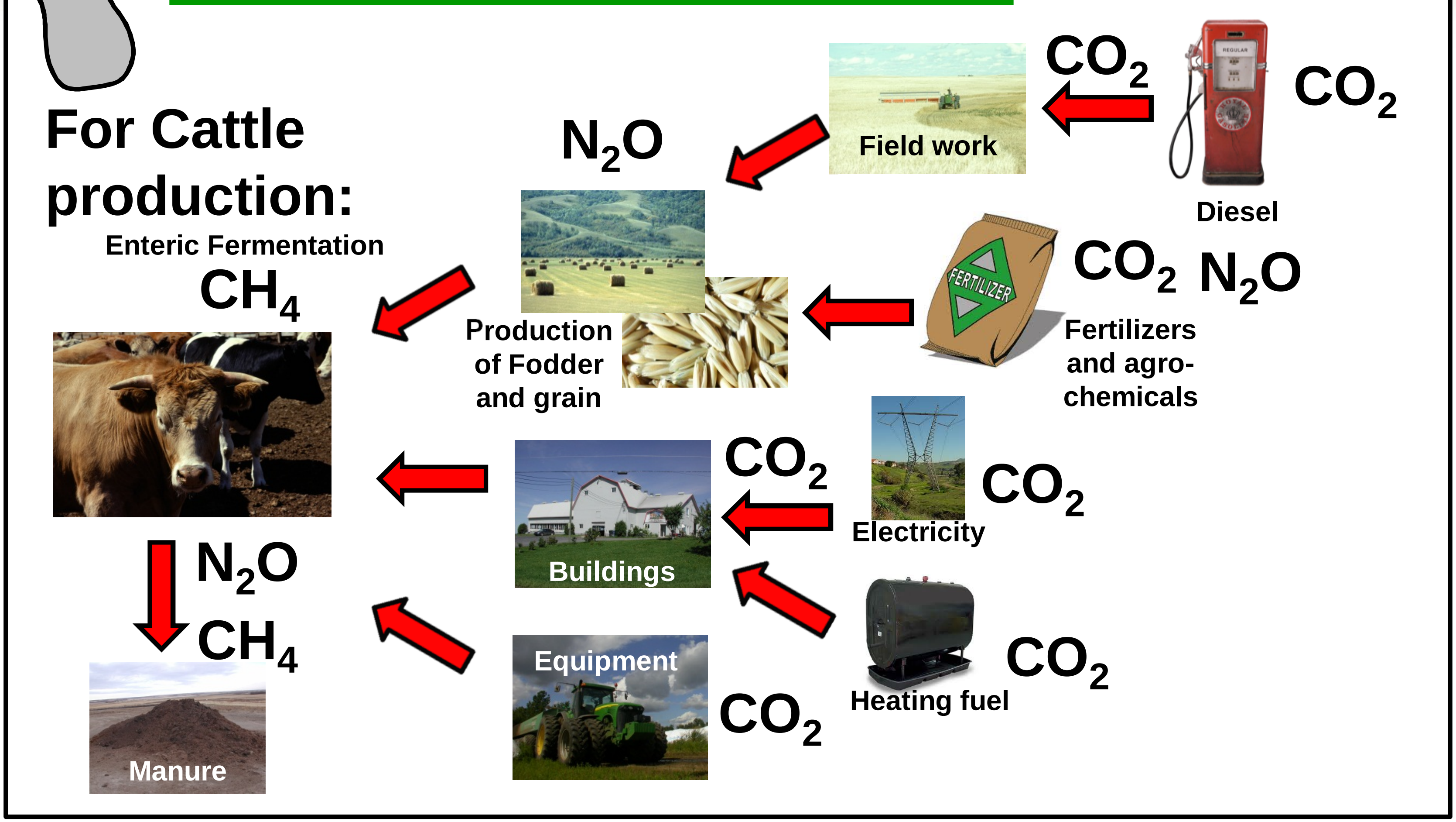
Use of Inventory for Footprinting

- Use of 2006 GL well suited for commodity-level analyses
  - ❖Grain, meat, milk, etc.
  - ❖Supply is from many farms
  - ❖Individual farms will not be competing based on C footprint
    - Most emissions in CO_2eq will have to be estimated as measurements infeasible
    - Inventory methods are well accepted basis for estimates

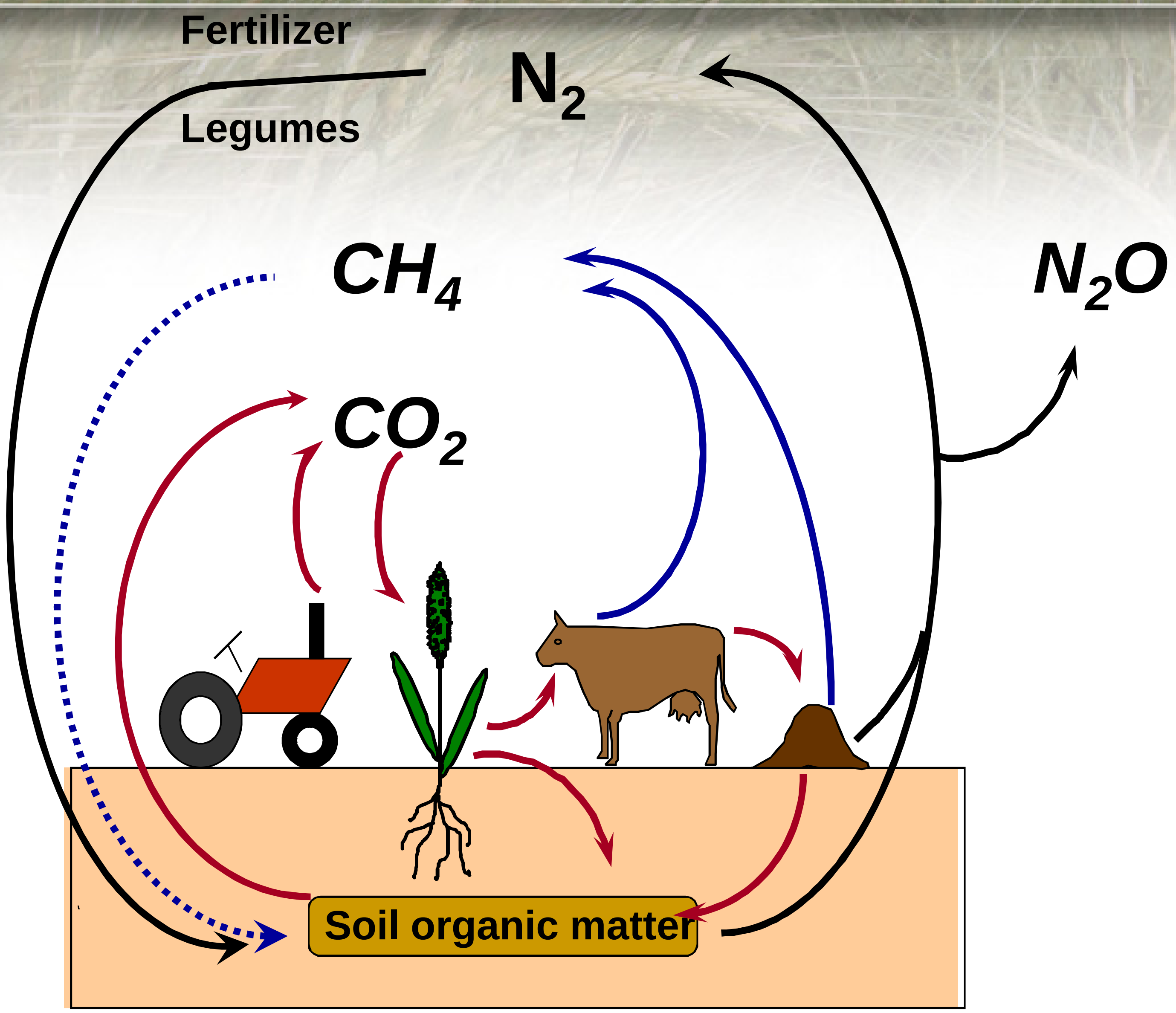
Set boundaries, example beef cattle



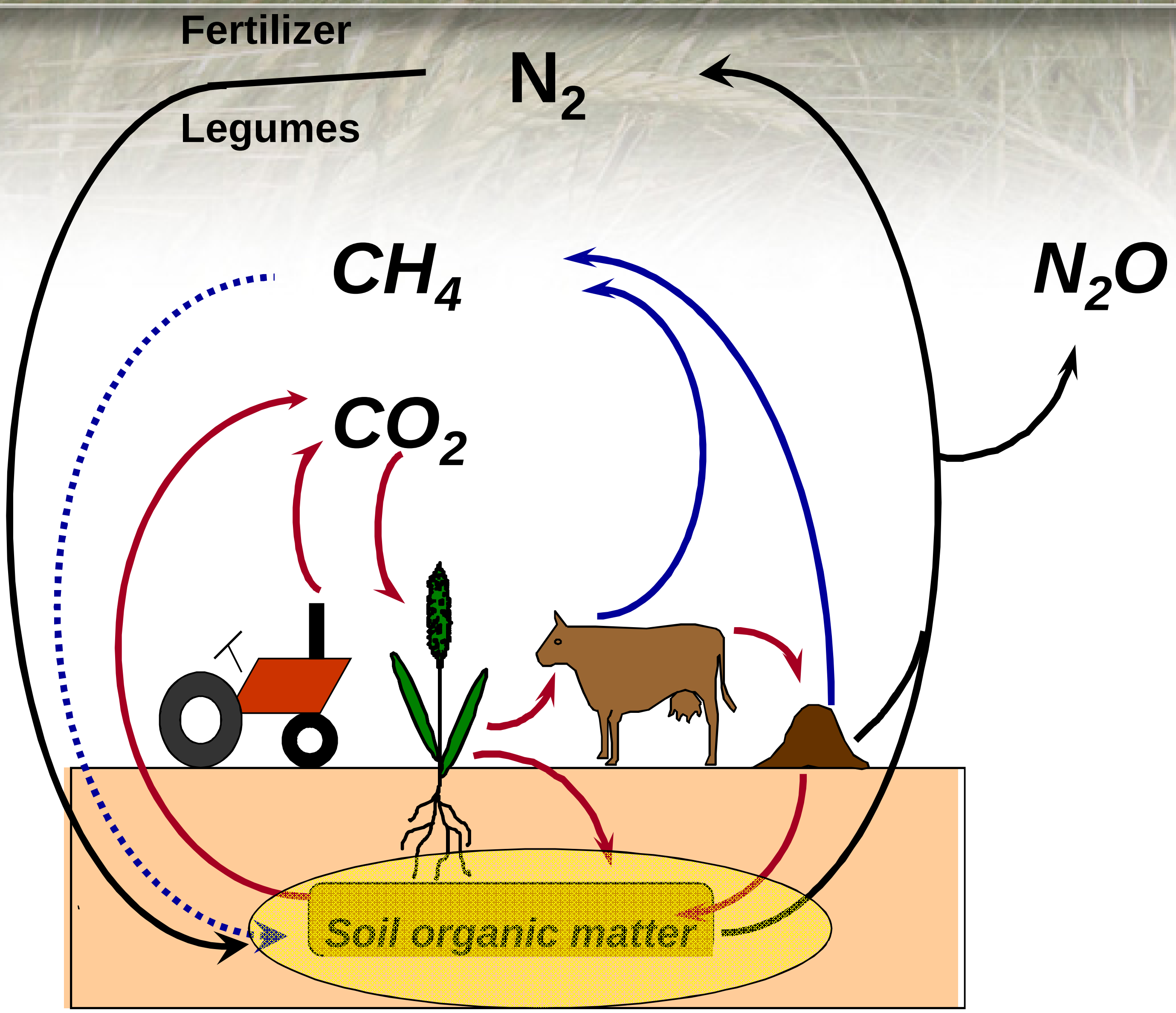
The total GHG emissions associated with a product or service, considering all relevant sources and sinks of emissions



Select methods from 2006 GL-based inventory for different relevant sources and gases



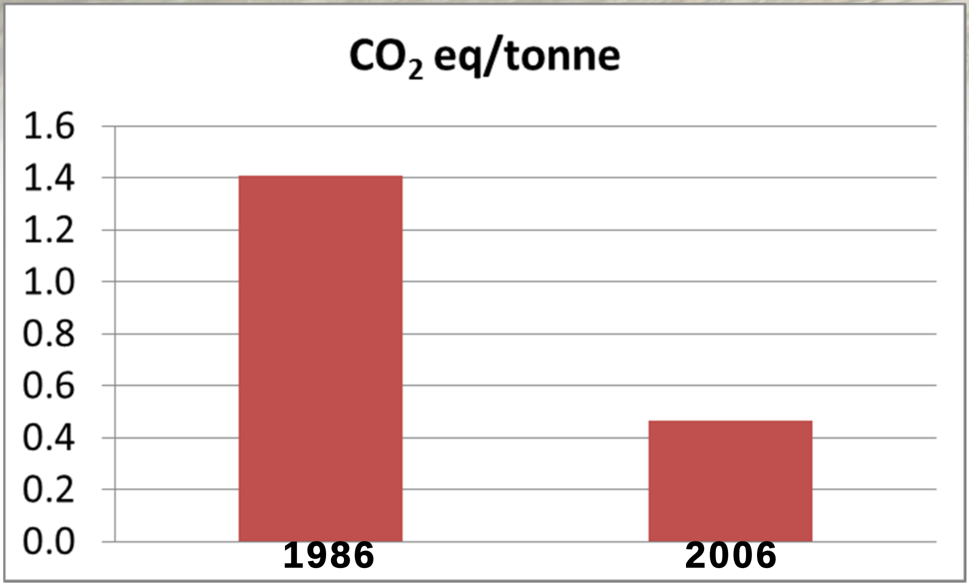
But C stock changes are difficult



C stock changes

- Legacy effects of past changes in land use and in management practices
- Difficult to attribute C changes to individual product
  - ❖ For example crops are grown in rotation so difficult to link C change to an individual crop in the rotation
  - ❖ Land-use change also difficult to relate to individual agricultural product
- Approaches used
  - ❖ Neglect some (e.g. LUC) or all or
  - ❖ Include a regional area average C change directly from the national inventory as the appropriate C change estimate for all agricultural land regardless of its history
    - C change due to “land occupation” by agriculture

Grain Crops

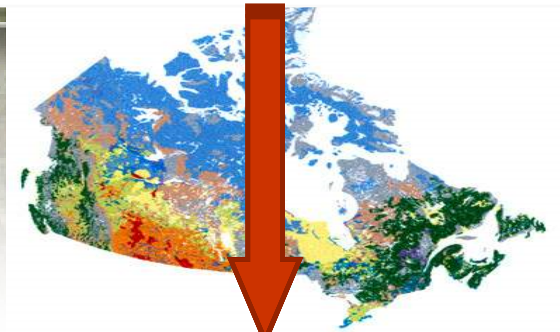


GHG intensity of canola (rapeseed) decreased by 2/3 from 1986 to 2006 (about ½ of reduction due to change of C stocks)

Source: Shrestha et al. 2014

LIVESTOCK SECTOR

Agricultural land



Livestock Crop Complex

Grain

- *Animal Diet*
- *Crop Yield*

$\text{Area}_{\text{Grain}}$

Roughages

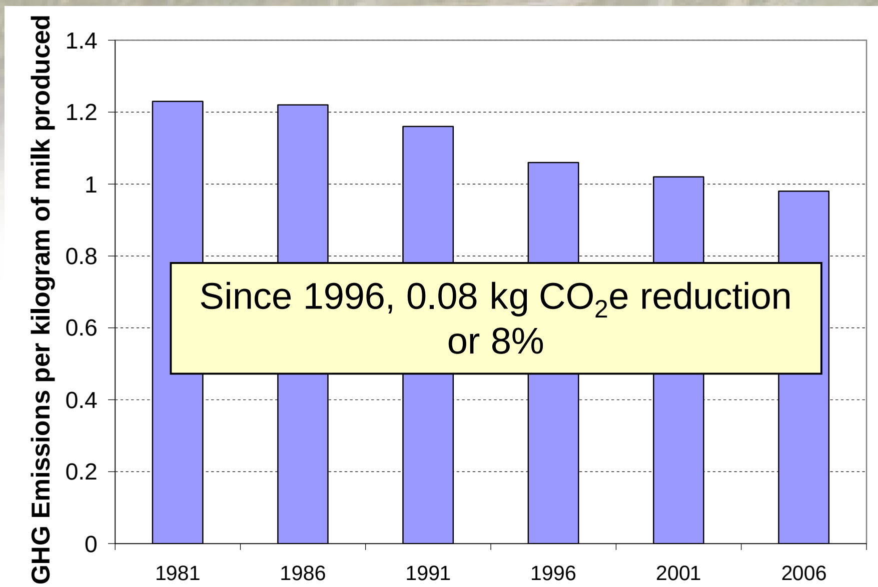
- *Statistics*
- *Land Allocation*

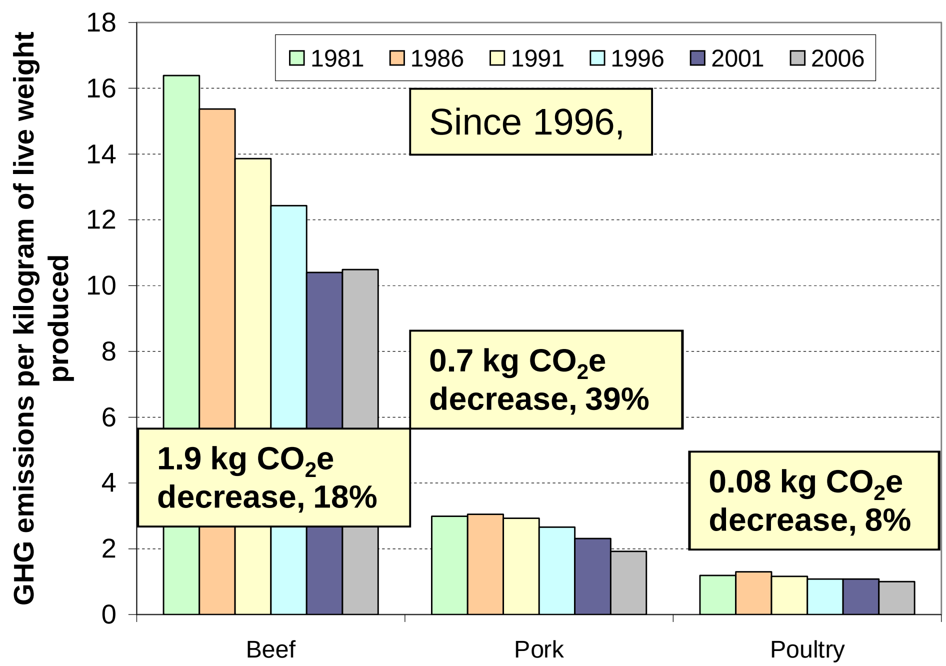
$\text{Area}_{\text{Roughages}}$

Notes:
1. Attributed areas do not necessarily occur where animals are raised due to off-farm feed purchases.
2. Every type of livestock in subnational region has same livestock crop complex

Source: Vergé et al. 2012a

Recently, significant gains in emissions per unit of product have been made





Source: Vergé et al. 2012b

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Summary

- Methods drawn from 2006 GL are useful for analysis of national and sub-national mitigation options and commodity-level footprints
  - ❖ Less useful for analysis for activities at finer resolution than the inventory, e.g. individual farm
  - ❖ AFOLU not fully adequate for either footprinting or policy purposes, need to capture fossil fuel emissions
- Methods are the best available for general use in the country so well accepted by practitioners, reviewers, and users.
  - ❖ Necessary for mitigation policy that is measured by changes in national inventory estimates
  - ❖ Particularly important for agriculture where non-CO_2 gases predominate
- Including C stock changes are problematic because the current change is a legacy of past changes to land use and land management.
  - ❖ Easy to apply the inventory generated estimates but not common approach for footprint/LCA analyses

Благодаря,
Merci