

C and Greenhouse Gas Accounting, Quantification, and Monitoring in Canadian Agriculture

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and many others

Agriculture & Agri-food Canada

¹ Ottawa, Ontario

² Swift Current, Saskatchewan

³ Lethbridge, Alberta



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Agriculture - 7% of Canadian Land Mass



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Canada has 45.9 M ha of Cropland



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Canada has 15.4 M ha of Natural Grassland for Pasture

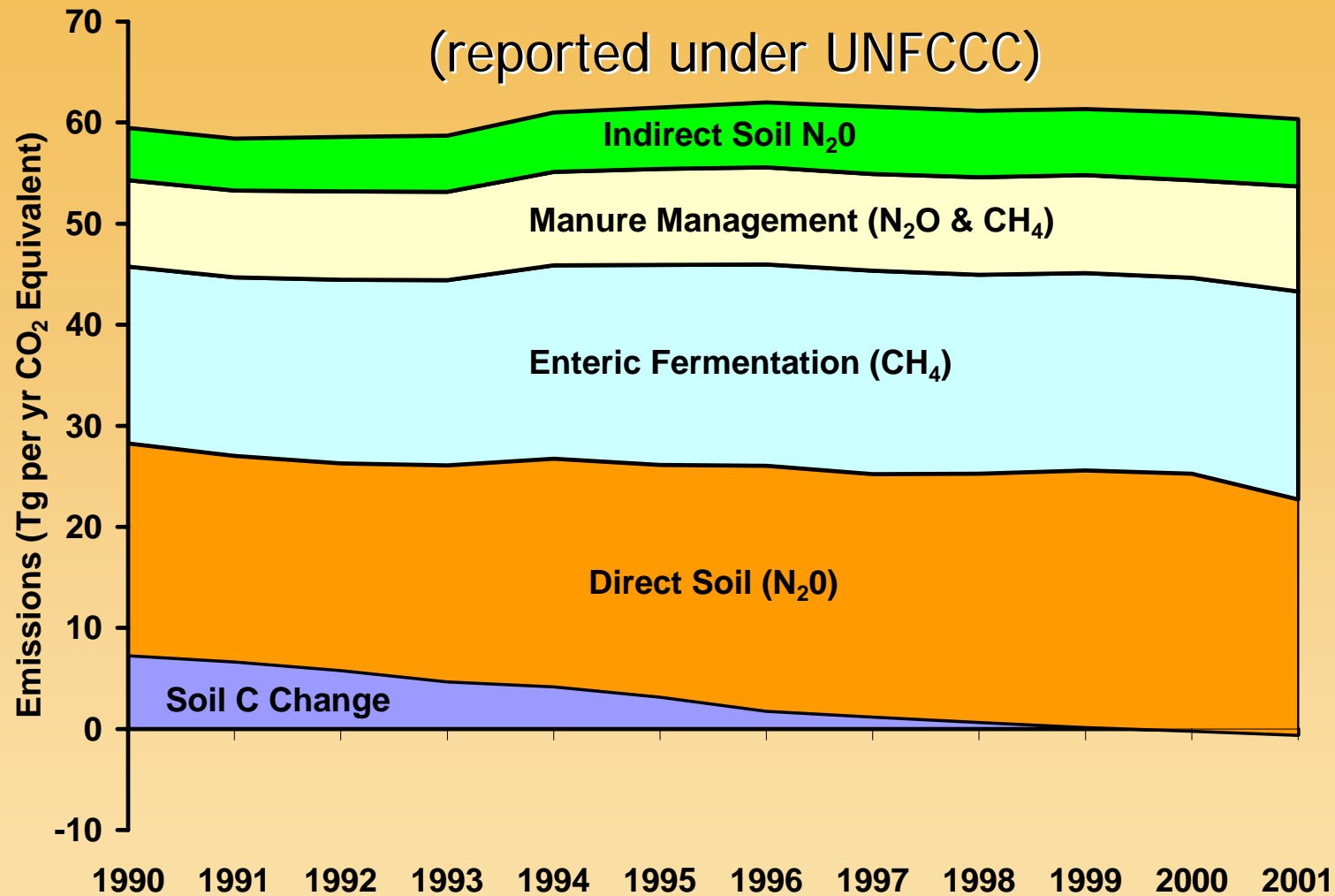


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Canada's Agricultural GHG Inventory



- Represents approx. 8-10% of total national emissions

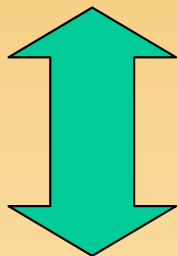
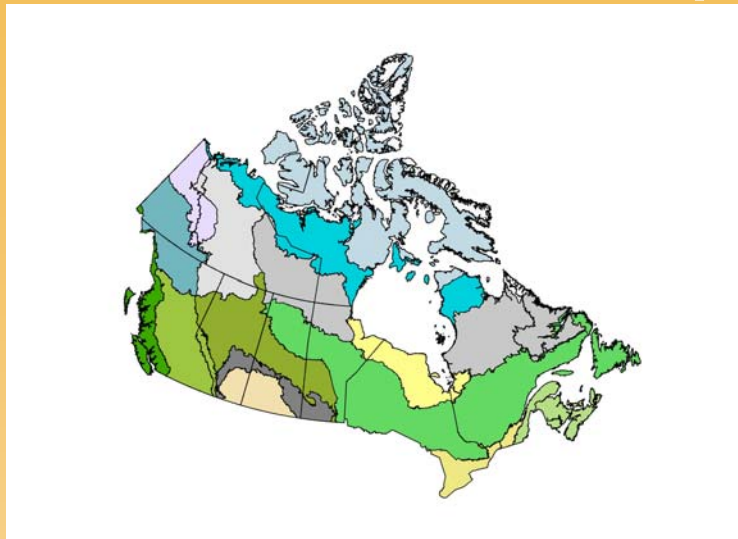


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Spatial Scale?



National or Regional Scale

- Reporting under UNFCCC and KP
- Government policies and environmental assessments

?

Pedon or Animal Scale

- Agricultural practices
- Plot or animal measurements
- Most process models



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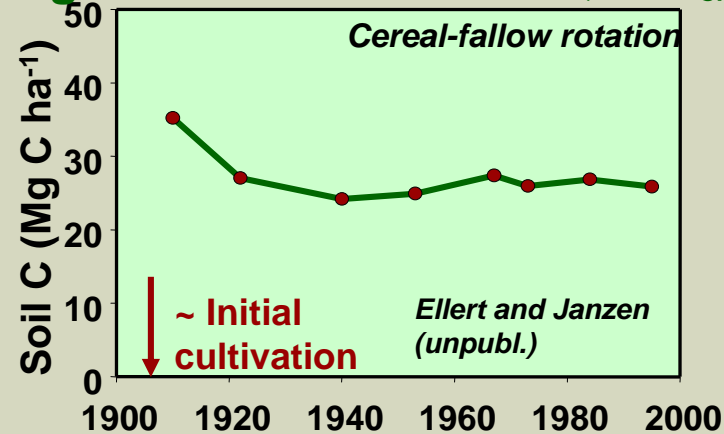
Temporal Scale?



$10^{-1} - 10^3$ h

**Biochemical
Cycling**

Organic C in surface soil (2000 Mg)



10^3 to 10^6 h

**Government Policies
Farm Management
National GHG Accounts**



10^6 to 10^{10+} h

**Biogeochemical
Cycling**



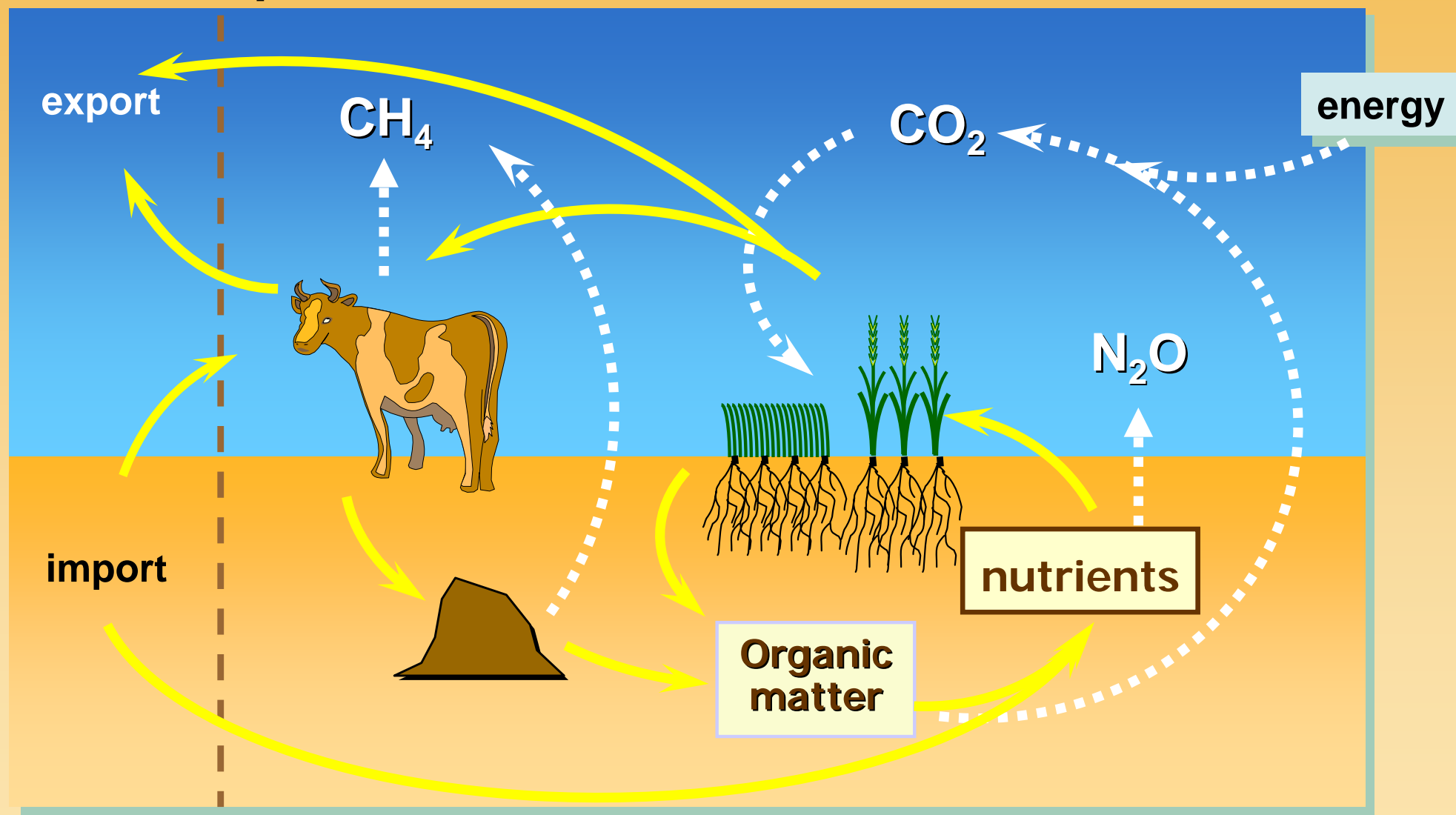
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Scale?

Which processes and GHG's?



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Scale?

- Appropriate scale ultimately determined by **funding**
 - National GHG accounting to support GHG policy development and UNFCCC and KP reporting that **accurately reflects on-farm management**
 - Follow IPCC Good Practice Guidance
 - Support good farm management that reduces net GHG emissions

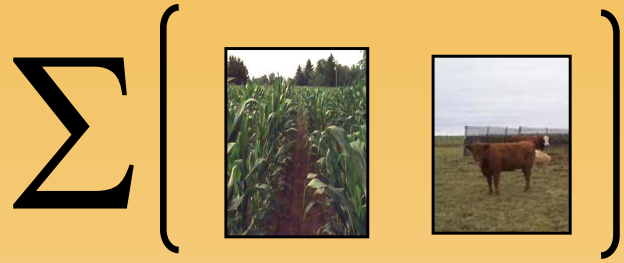


Scale – Canadian Approach

- **Integrative analysis** of all GHG's
- **Aggregate** emissions to produce accounts for international reporting and policy analysis
- Increase support of more **fundamental GHG research at various scales** to improve quantification and reduce uncertainty
 - Fine scale to improve estimators
 - Course scale to help verify aggregated estimates



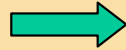
Canada has Three Interrelated Agricultural GHG Quantification/Accounting Thrusts



- **NCGAVS Project**



- **Virtual Farm Project**



- **Various science projects**



NCGAVS_("en-gavs")

National Soil Carbon and Greenhouse Gas Accounting and Verification System for Agriculture

- Objective:
 - A scientific, transparent, and verifiable accounting system for reporting soil carbon stocks, carbon stock changes, nitrous oxide and methane emissions for Canadian agricultural land
 - To meet international commitments under the Kyoto Protocol and in support of sustainable agriculture
- Research Branch of Agriculture and Agri-Food Canada



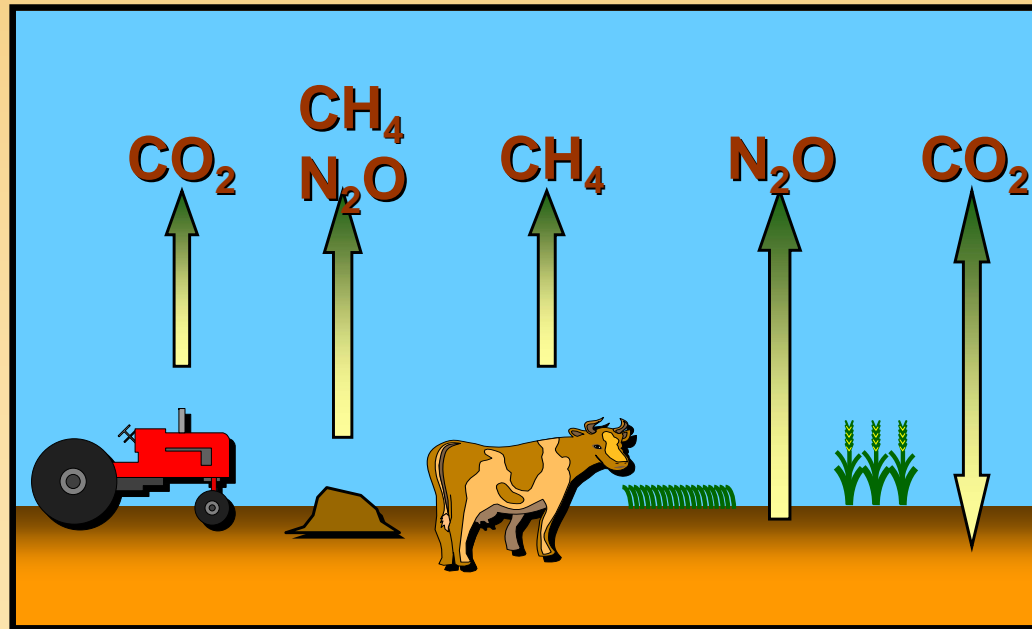
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NCGAVS - Scope

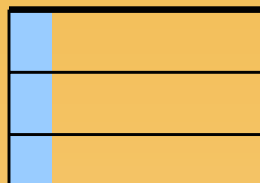
- CH_4 , N_2O , and CO_2 emission/removals from management in agriculture
- Land-use change (LUC)
 - Data, C accounts and information transfer with other national C inventories (forest, other land uses)
 - Take on accounting for land entering agriculture



NCGAVS – Basics

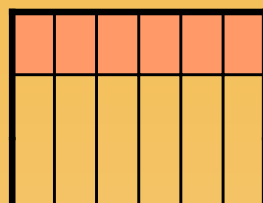
- Data Intensive
- Accounting from the **bottom up**
- IPCC Tier-2 methodology
 - Factors (coefficients) multiplied by amount of an agricultural activity
 - (Tier-3 to derive some factors)
- Completed by March 2006





Soil Landscapes of Canada (SLC)
Polygon Land Database

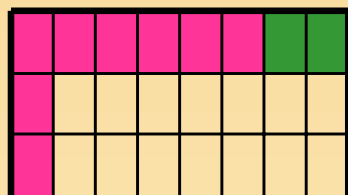
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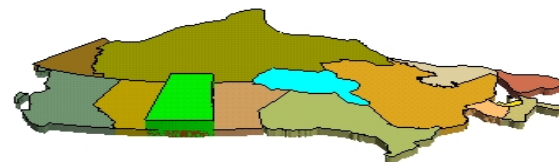
SLC Polygon Agricultural
Activity Database



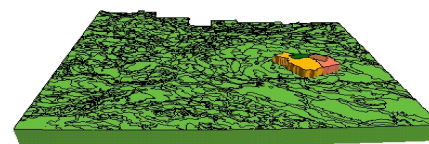
Estimators for Deriving
GHG Emission/Removal Factors



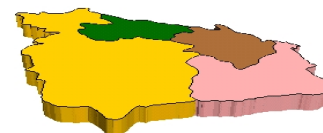
Activities linked to GHG Factors



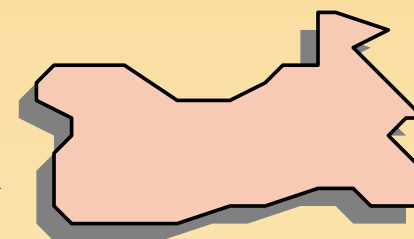
National
Account



Provincial
Account



Regional Account
(Group of SLC Polygons)



GHG Account
for SLC Polygon



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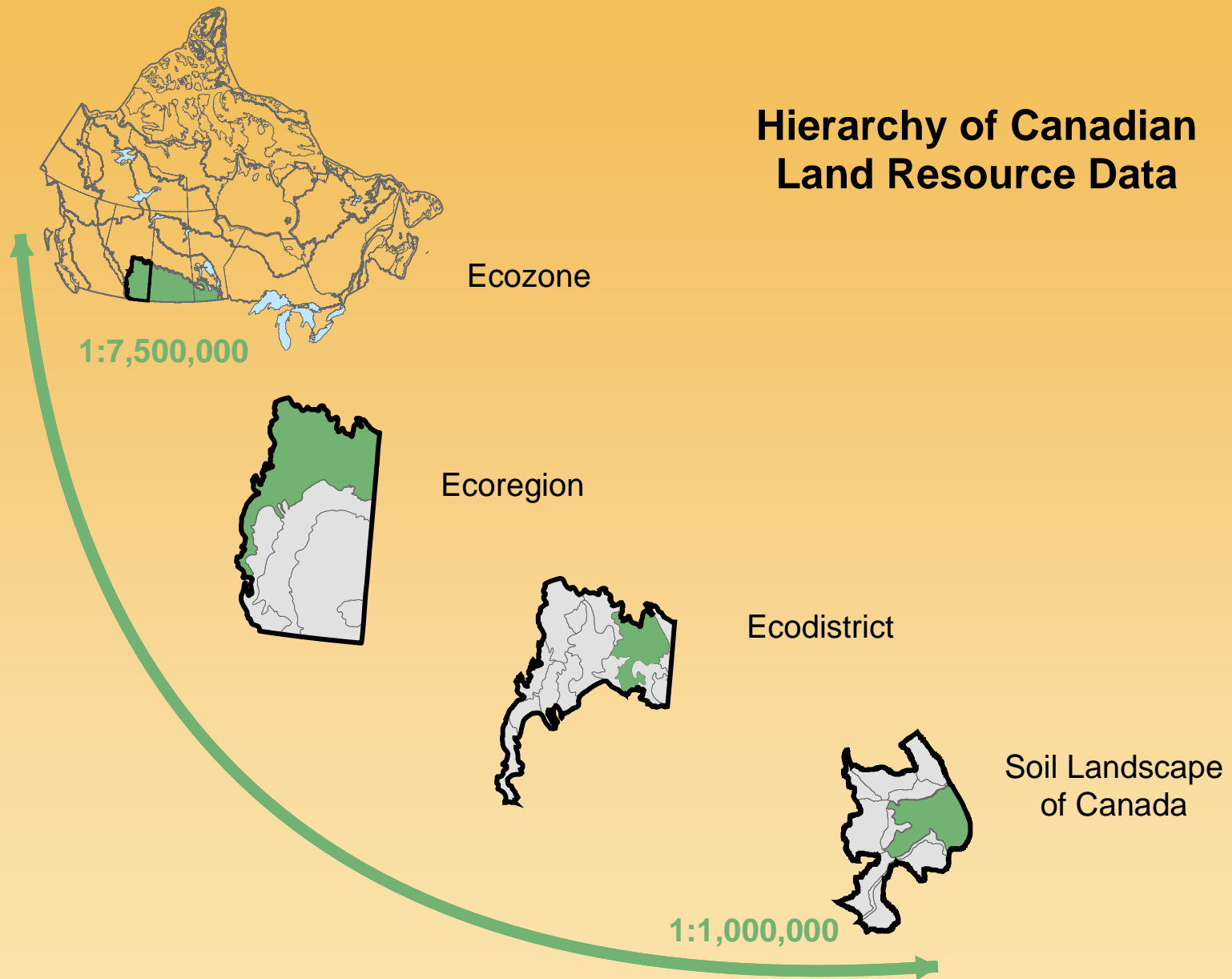
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Agriculture Activity Data Sources

- Census of Agriculture
 - Every 5 yr from 1951 (10 yr 1871-1951)
 - Enumerates all farms
 - Information on crops, livestock, costs and returns, farming practices
 - Concurrent with general population census
- Annual agricultural production and inputs statistics
 - Industry associations
 - Regular surveying of crop areas and production
- Sporadic farm surveys on farming practices
- Expert knowledge
- Remote Sensing



Hierarchy of Canadian Land Resource Data



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Landscape

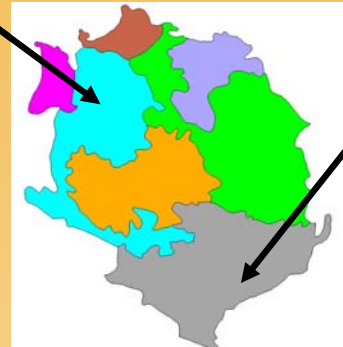


Soil

Landscape



Soil

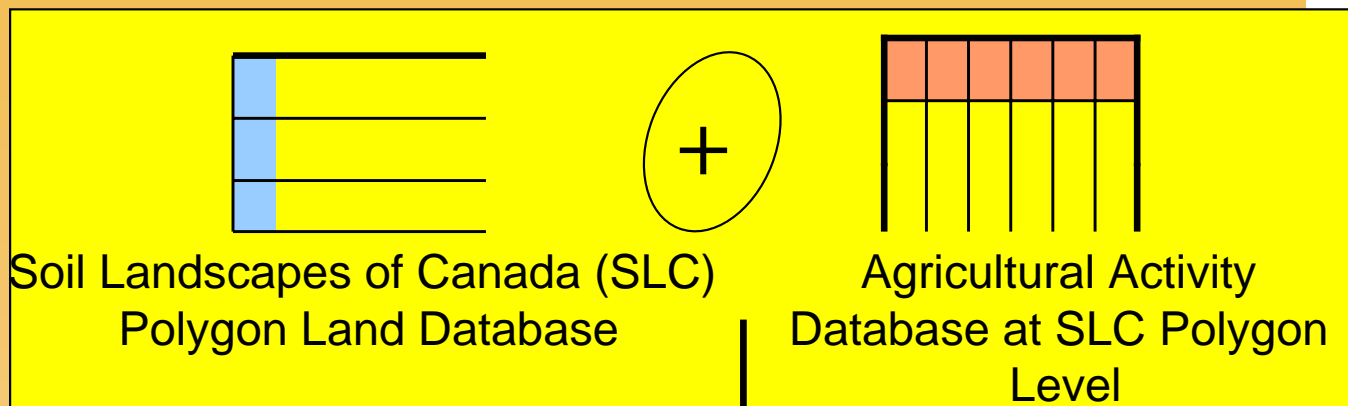


SLC polygons

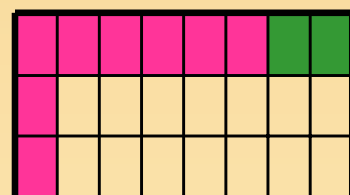
Full array of attributes within Soil Landscapes of Canada (SLC) polygons including:

- Soil components
- Typical C contents under native and dominant agricultural use
- Toposequences, surface form
- Texture, pH

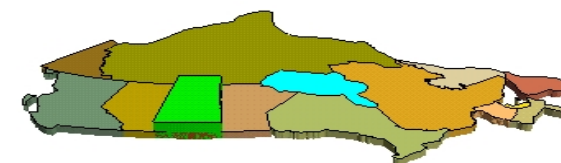




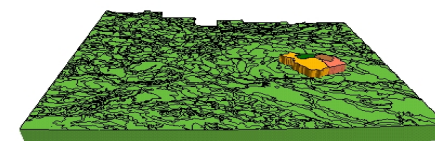
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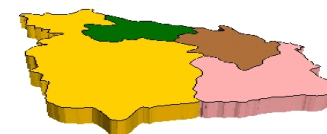
Activities linked to GHG Factors



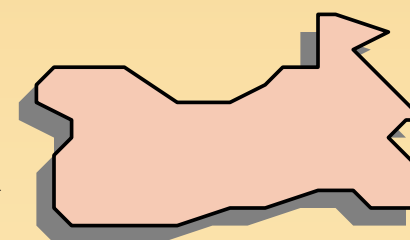
National
Account



Provincial
Account



Regional Account
(Group of SLC Polygons)



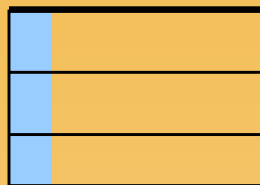
GHG Account
for SLC Polygon



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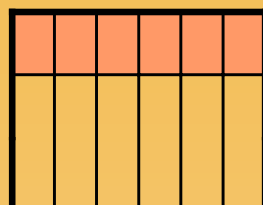
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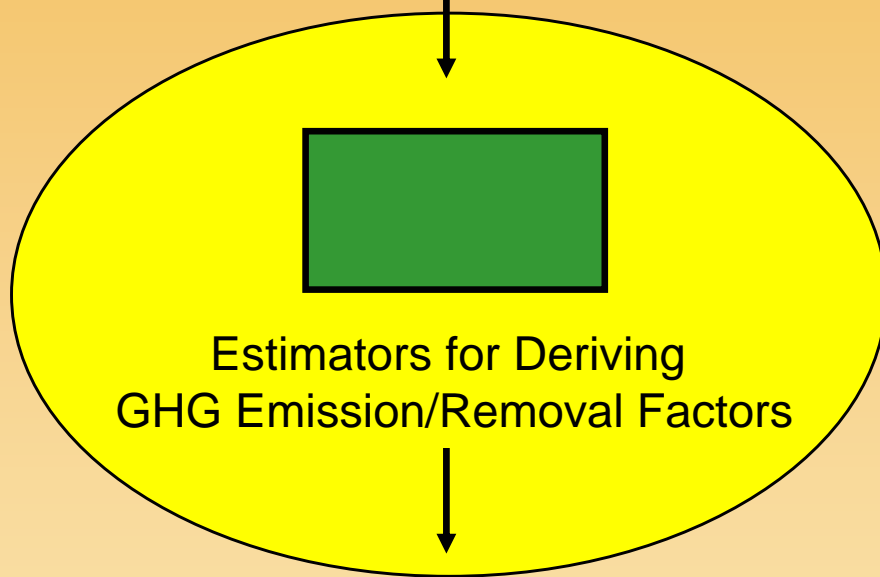


Soil Landscapes of Canada (SLC)
Polygon Land Database

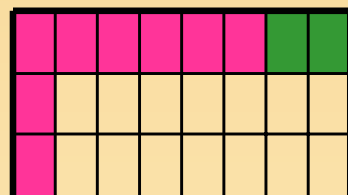
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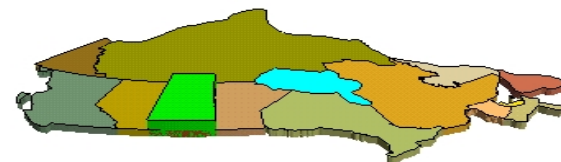
SLC Polygon Agricultural
Activity Database



Estimators for Deriving
GHG Emission/Removal Factors



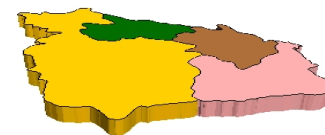
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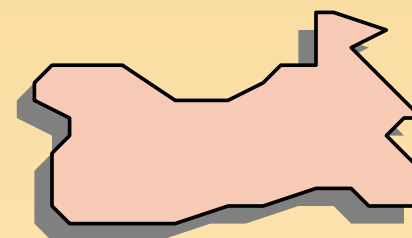
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GHG Account
for SLC Polygon

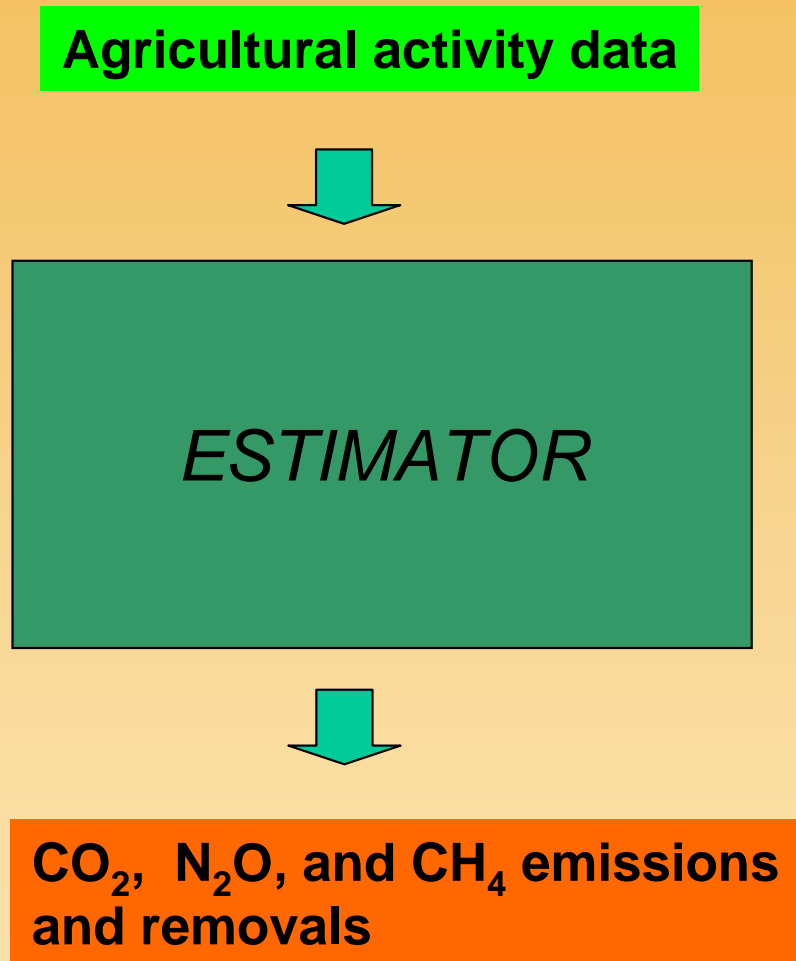


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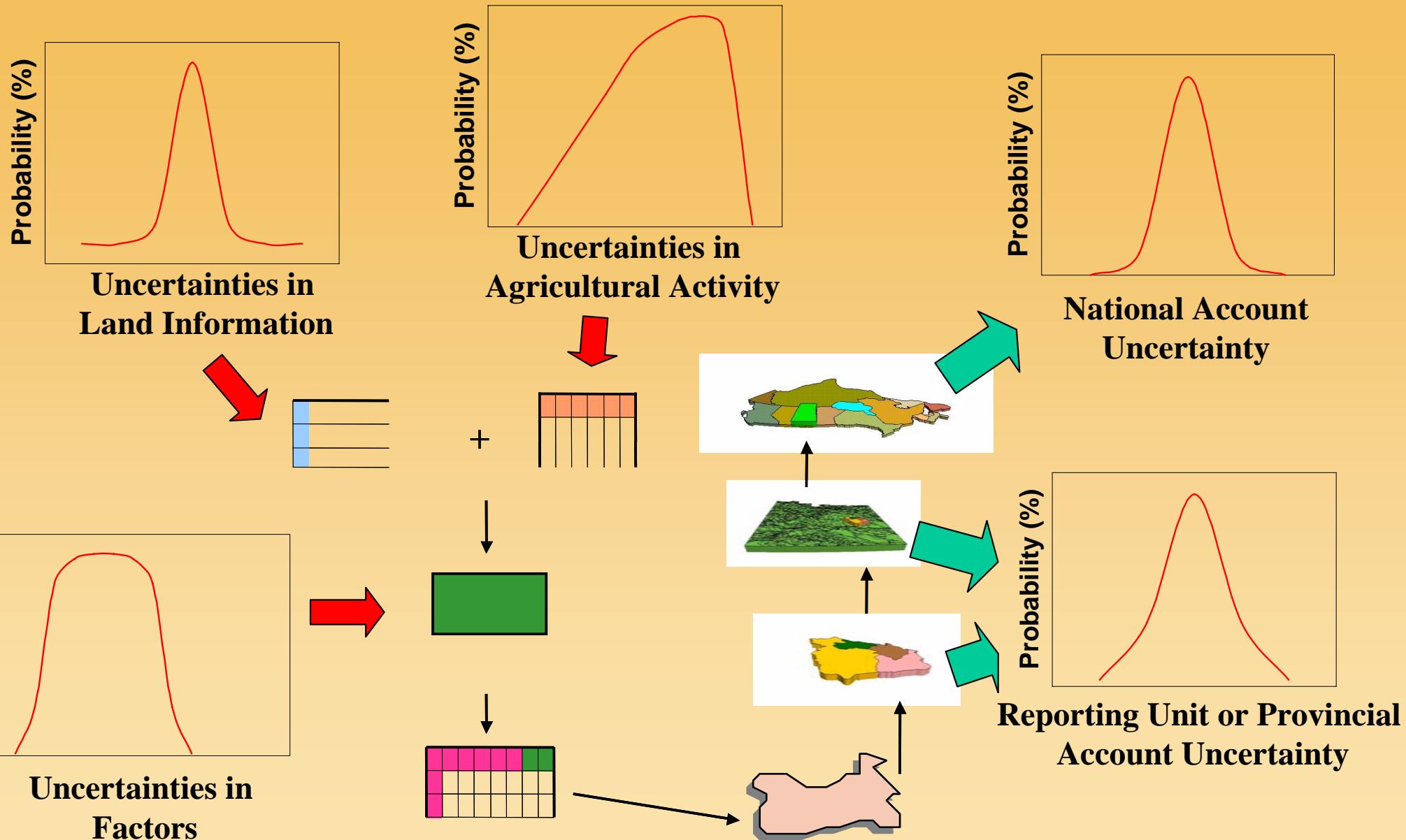
Estimators



- Estimator can be:
 - Empirical relationship
 - Canada-specific data and methods
 - Mechanistic models
 - DAYCENT for C change and N₂O
 - Canada-specific application



NCGAVS Uncertainty through Monte Carlo Analysis



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Verification

- Transparency
- Consistency, Comprehensiveness, Comparability
- Quality Assurance/Quality Control
- Validation of estimators, continual accuracy assessment against ongoing measurements

NCGAVS Prototype



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Map

- [Map](#)
 - [Scope](#)
 - [Scenario](#)
 - [Allocation](#)
 - [Reports](#)
 - [HOME](#)
-
- Maintenance**
- [Climate](#)
 - [Soils](#)
 - [Landcover](#)
 - [Modeling](#)
 - [Ag <-> Forest](#)
 - [Databases](#)
 - [Documentation](#)
 - [Management Practices](#)

Layers

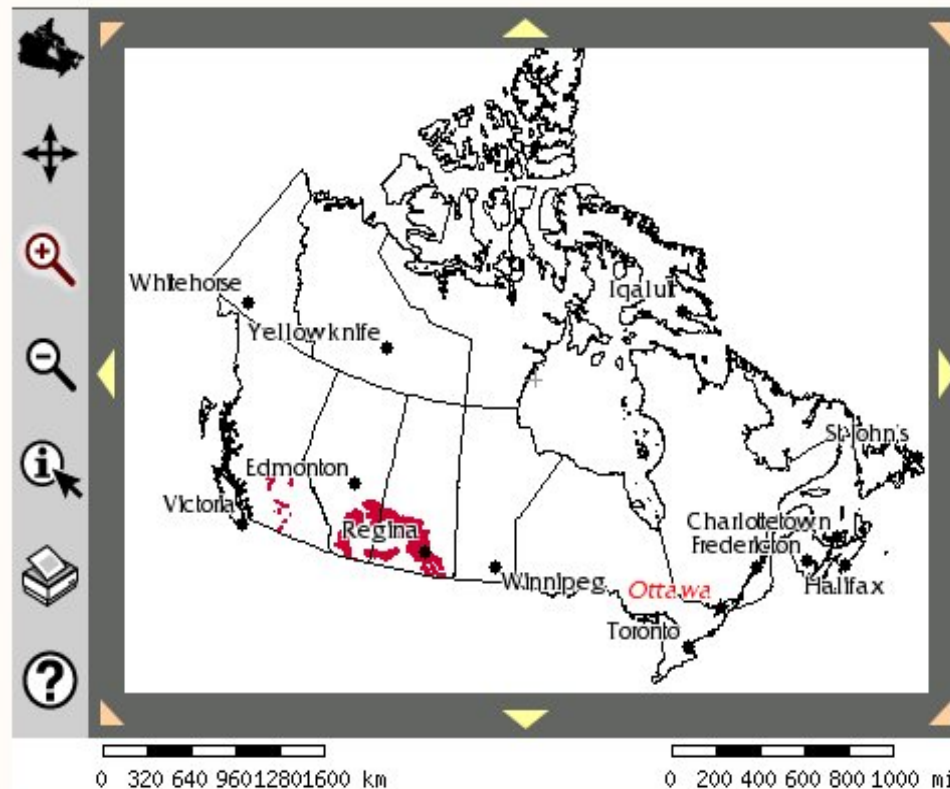
Foreground:

- none
- Ecozones
- Ecoregions
- Ecodistricts
- SLC
- Drainage
- SL Pilots
- SL Query

Background:

- Bathymetry
- Land Use
- None

Reference Map



QUERY Administrative

Province

Ecological

Ecozones

EcoRegion

Enter Ecodistrict

Soils

Dark Brown Chernozemic

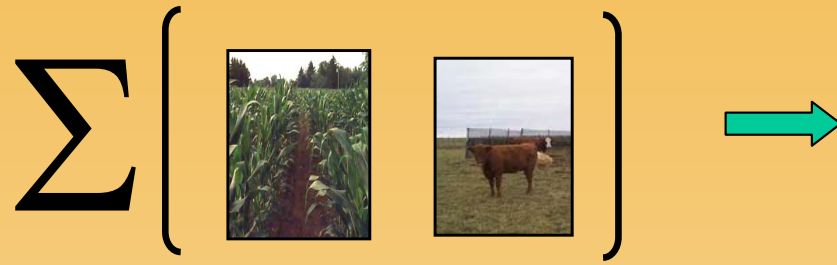
Texture

Landscape

Parent Material

Enter SLC

Canada has Three Interrelated Agricultural GHG Quantification/Accounting Thrusts



- **NCGAVS Project**



- **Virtual Farm Project**



- **Various science projects**



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Virtual Farm Project

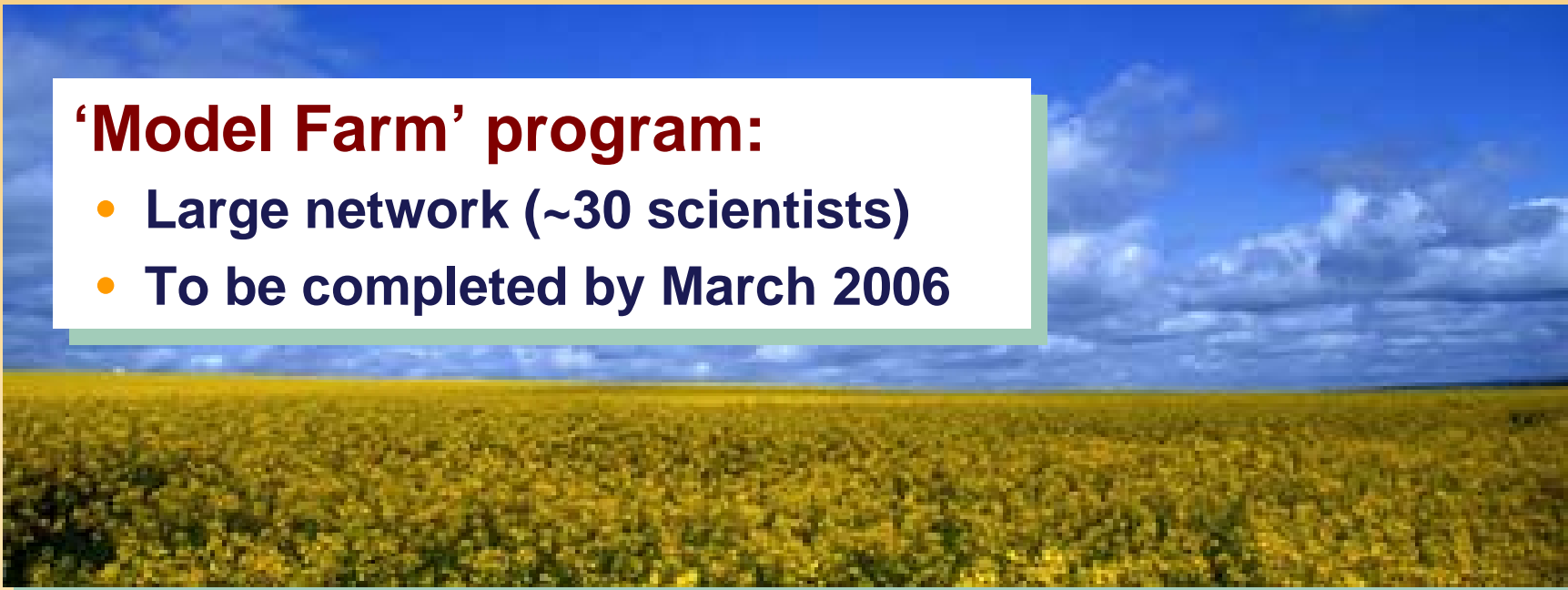
~~The Model Farm~~ Virtual Farm:

- What is it?
- What will it look like?
- How do we hope to build it?



'Model Farm' program:

- Large network (~30 scientists)
- To be completed by March 2006



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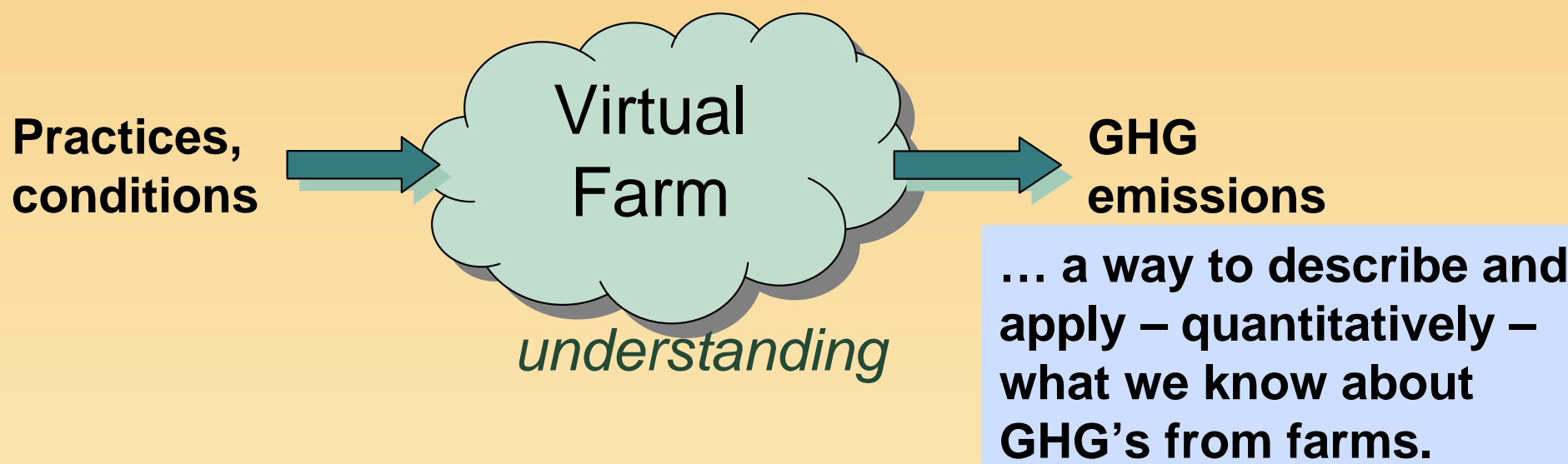
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The Virtual Farm:

What is it, exactly?

Virtual Farm:

- A mathematical description of biophysical processes **on a farm**, predicting GHG fluxes as a function of practices imposed



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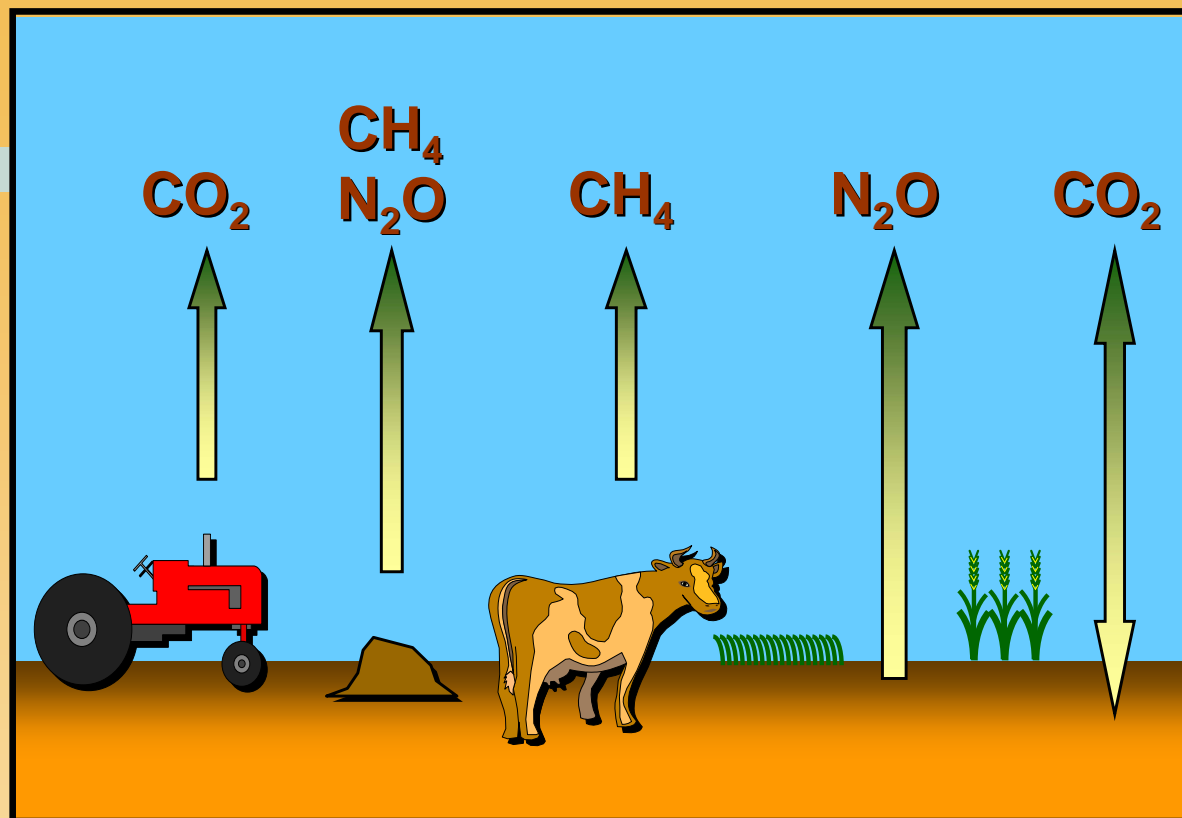
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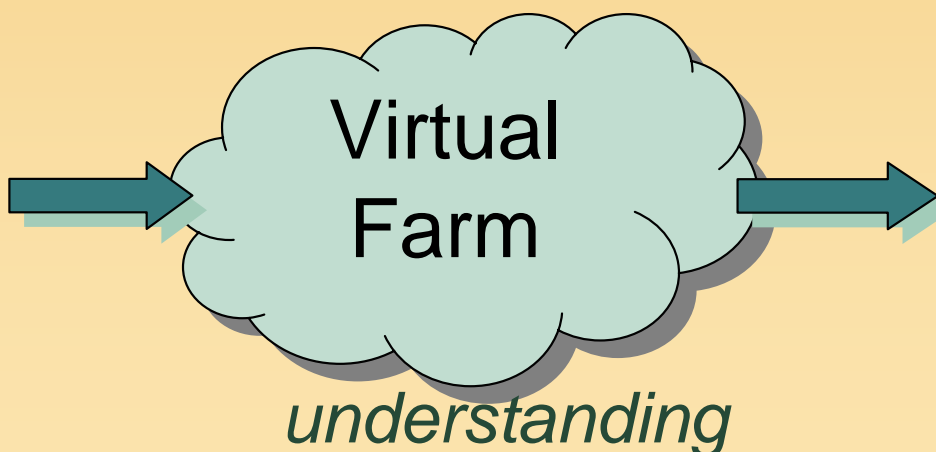
The Virtual Farm:

Why build it?

- Estimate 'whole-farm' emissions
- Find practices that reduce emissions, with emphasis on:
 - Future (*what if?*)
 - Local conditions
 - Systems (*packages*)



Practices,
conditions



GHG
emissions

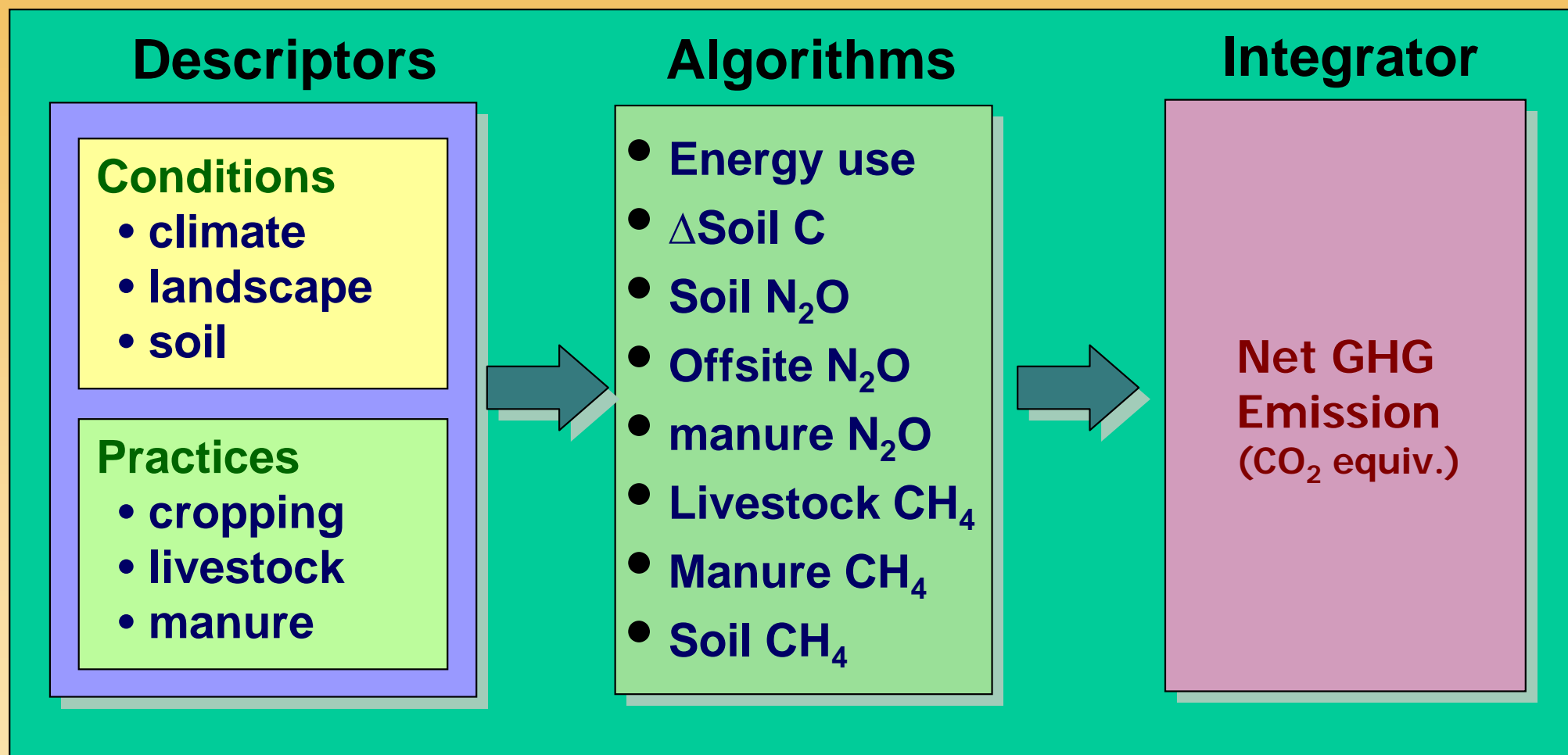


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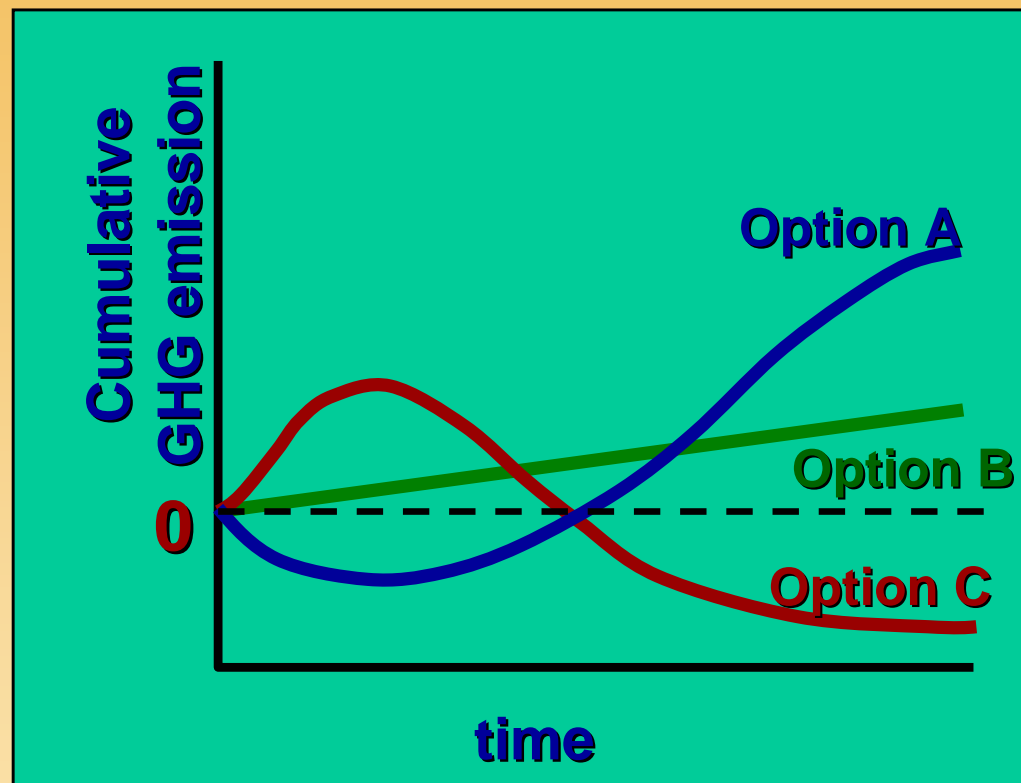
The Virtual Farm: What might it look like?



What might it look like?

Features:

- 'Sees' into the future (and the past)



scenarios

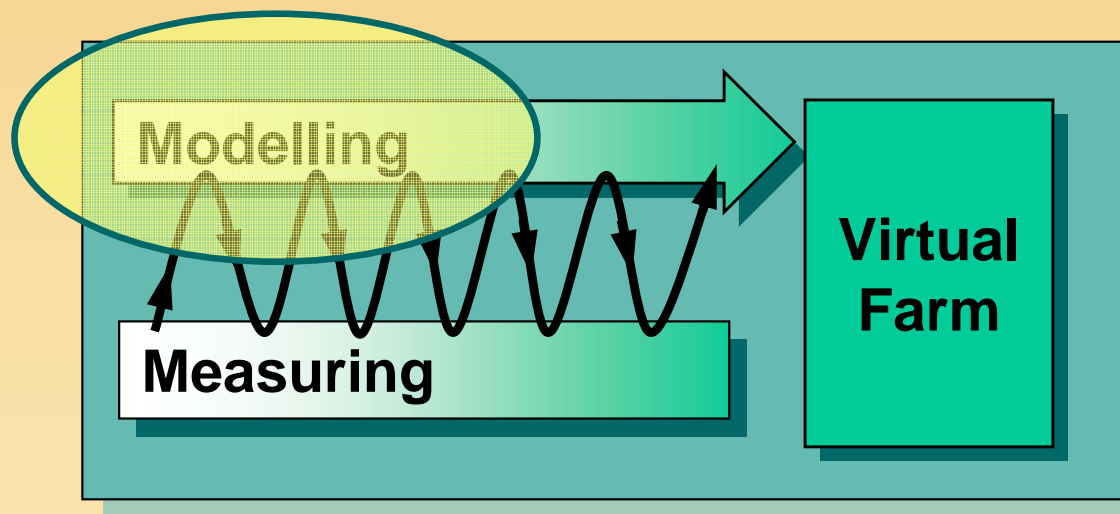
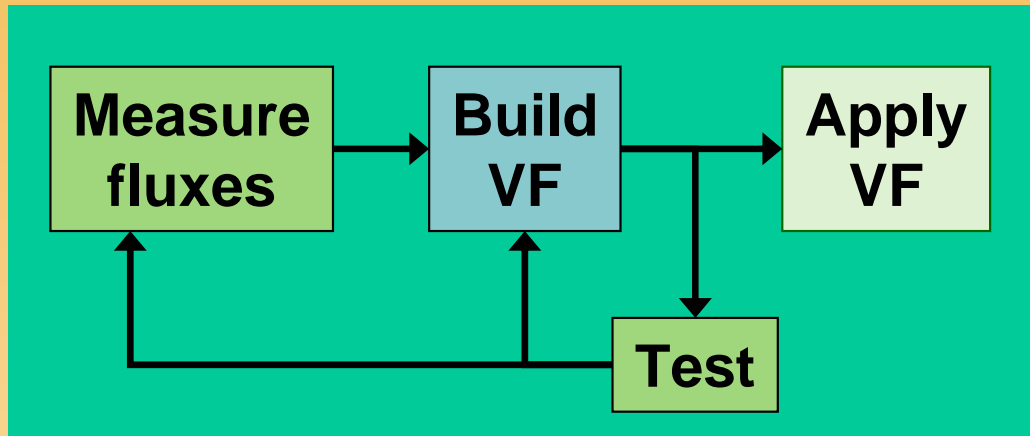


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How do you build Virtual Farm?

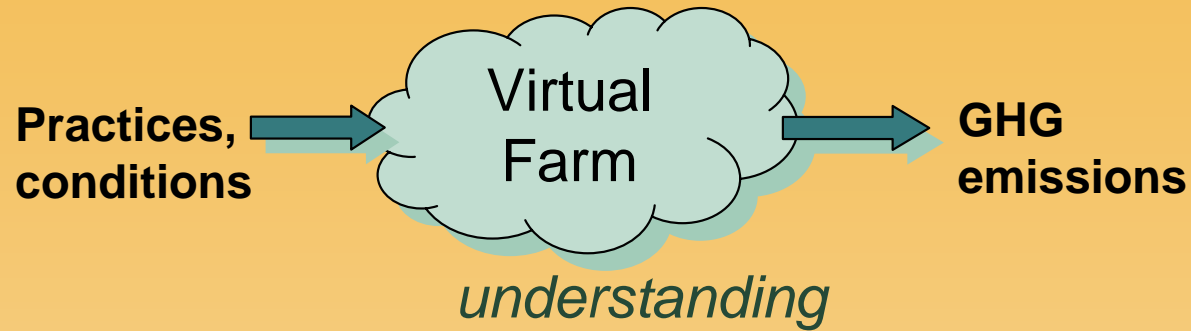


Output

- Virtual Farm
- web-based calculator



The Virtual Farm: deliverables



Output

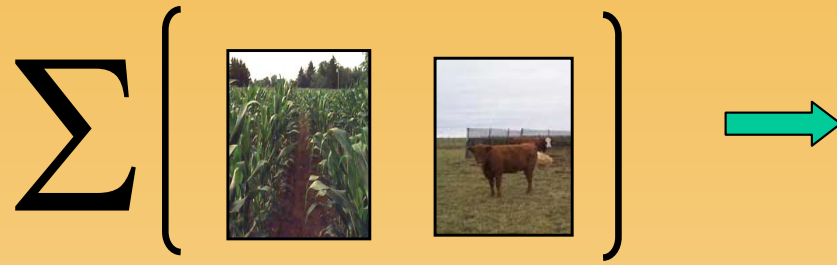
- Understanding, expertise
- Estimators
 - **GHG calculator**
 - **Virtual Farm**
- Communications

- static
- → practitioners

- Dynamic
- → Science, policy



Canada has Three Interrelated Agricultural GHG Quantification/Accounting Thrusts



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Various GHG Research in Support of Quantification

- Such research major part of Virtual Farm
- Standard Methodologies
 - NCGAVS funded soil C change and direct N₂O emissions
- PERD, CFIA, BGSS (NCGAVS-funded)
- BIOCAP
 - Consortium of Universities, Government, and Industry
- Etc.



Outstanding Research Questions

- Monitoring for verification: feasible?
- Permanence of management practice
- “Representability” of plot level to aggregation and scaling-up

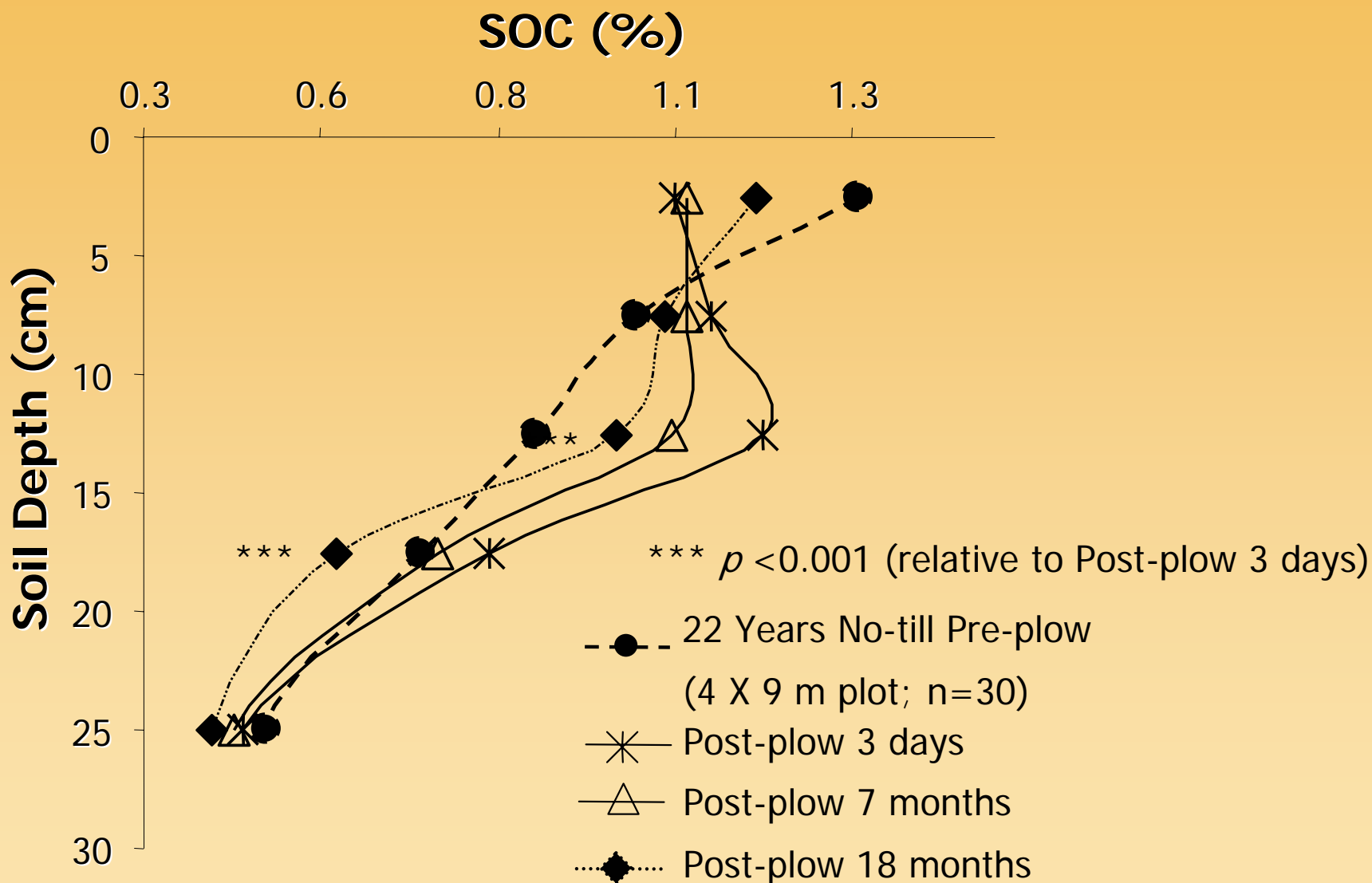


Canada's Approach to Monitoring

- For C: *The Canadian Information and Measurement System for Verifying Soil Carbon Stock Change*
- Database development and continuation of measurement of existing long-term research sites across Canada
- Continuation of measurement of Prairie Soil Carbon Balance sites
- ^{13}C labelling experiments



Permanance? : Sandy Loam NT Plowed Once



VandenBygaart and Kay 2004 SSSAJ

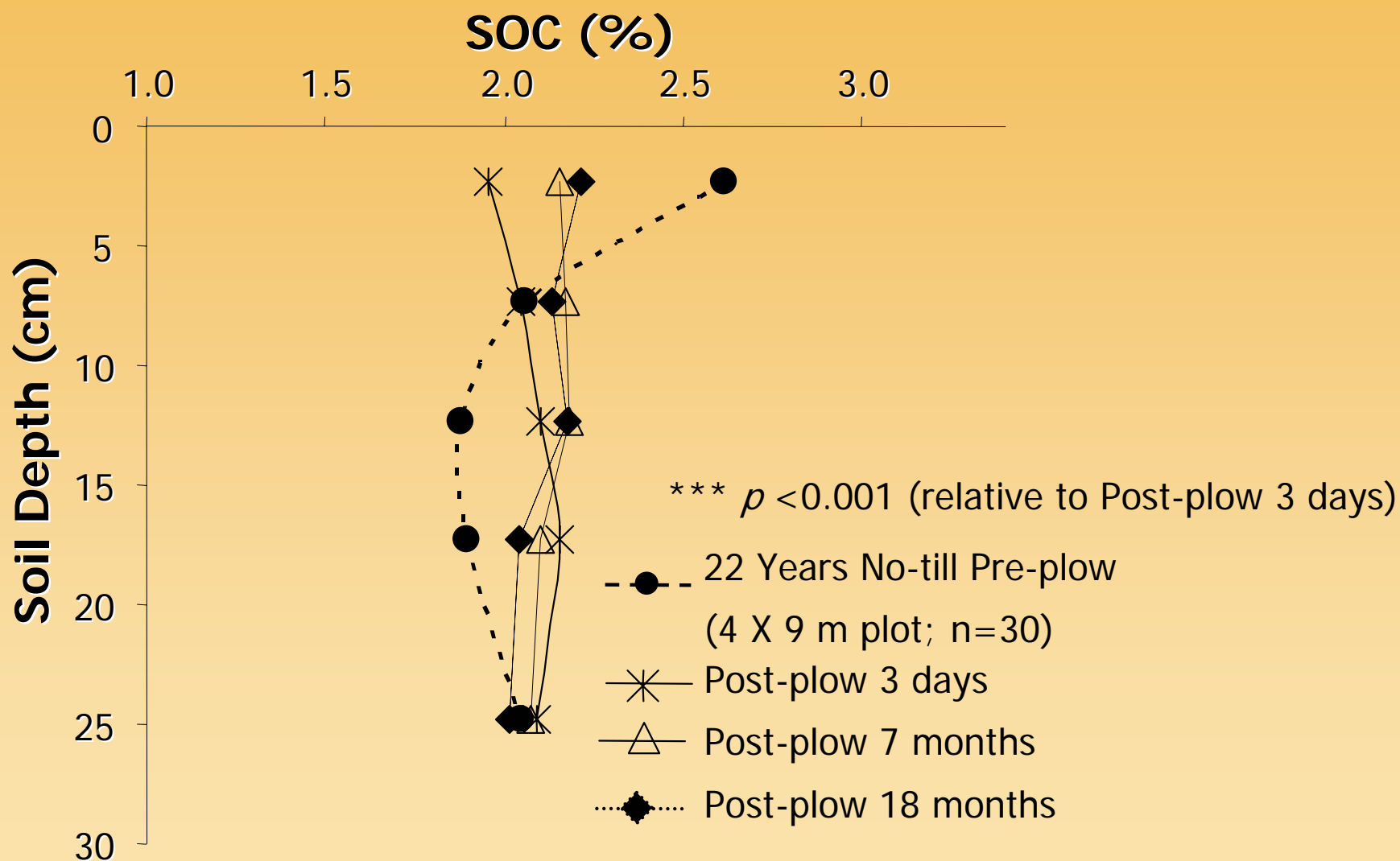


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Permanance? : Clay Loam NT Plowed Once



VandenBygaart and Kay 2004 SSSAJ



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Long-term Research Plots



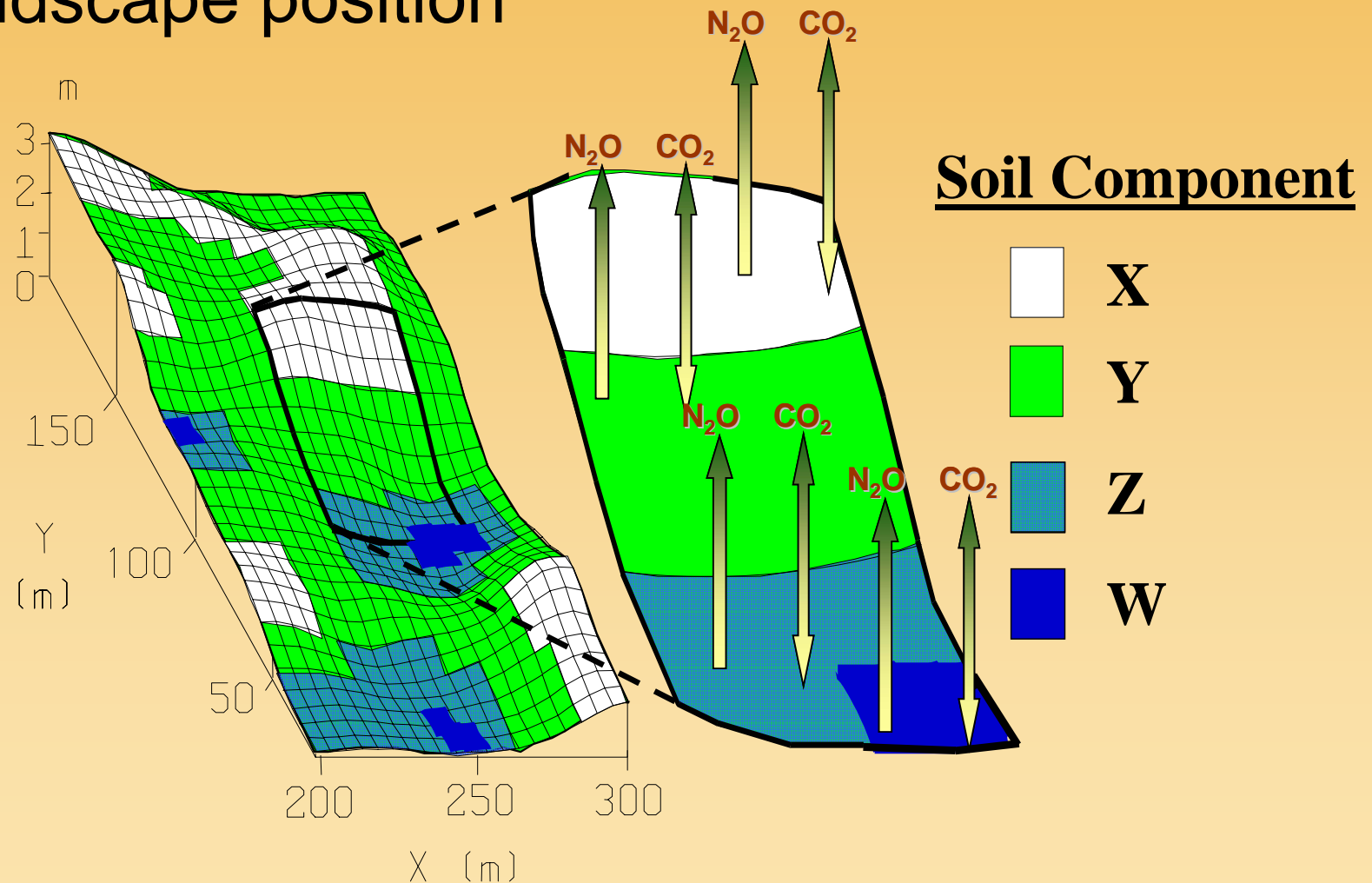
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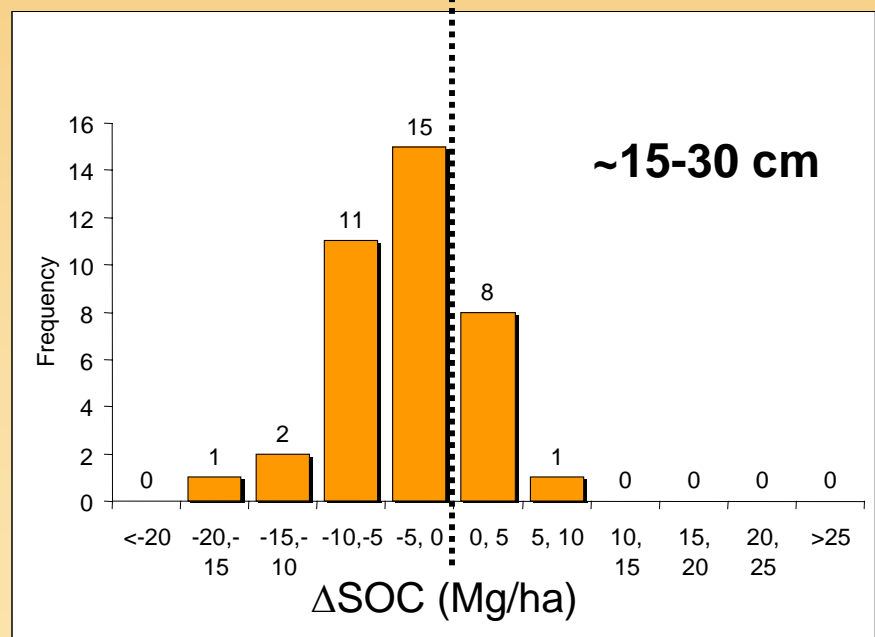
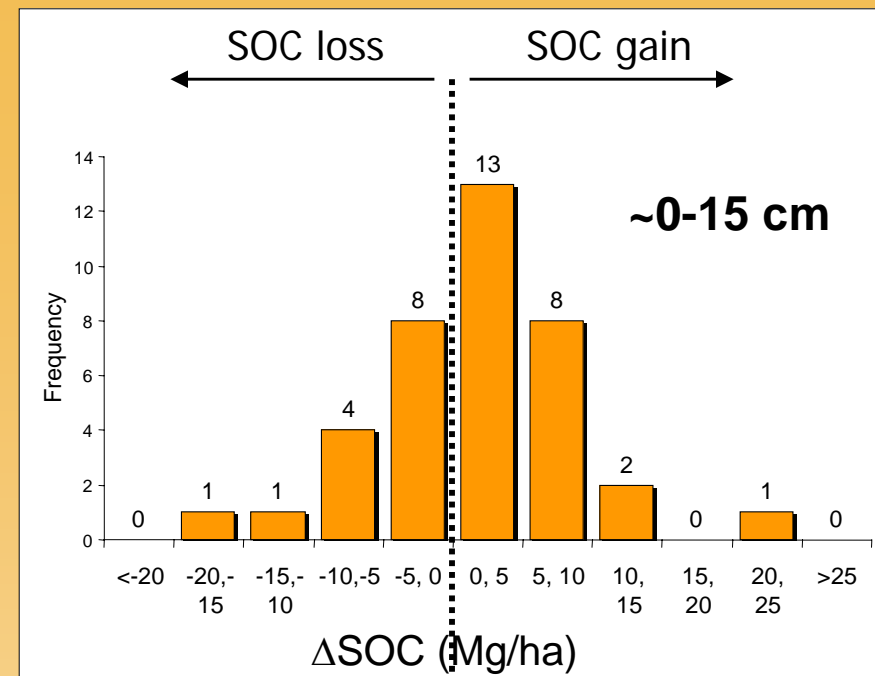
Landscape Reality

- Sources and sinks of GHG's dependant on landscape position



- Four fields converted to NT 1985 sampled at **variable landscape positions**; sampled again 2000
- Net changes in SOC stock showed general increase in top 15 cm but **concomitant loss** from 15 to 30 cm

VandenBygaart et al. 2002
Soil & Tillage Research



Summary

- Canada committed to provide rigid, transparent and verifiable accounting system for GHG's (NCGAVS)
- Process and modeling work continues – filling gaps of knowledge and reducing uncertainties (Model Farms and others)
- Still many pertinent and challenging research questions

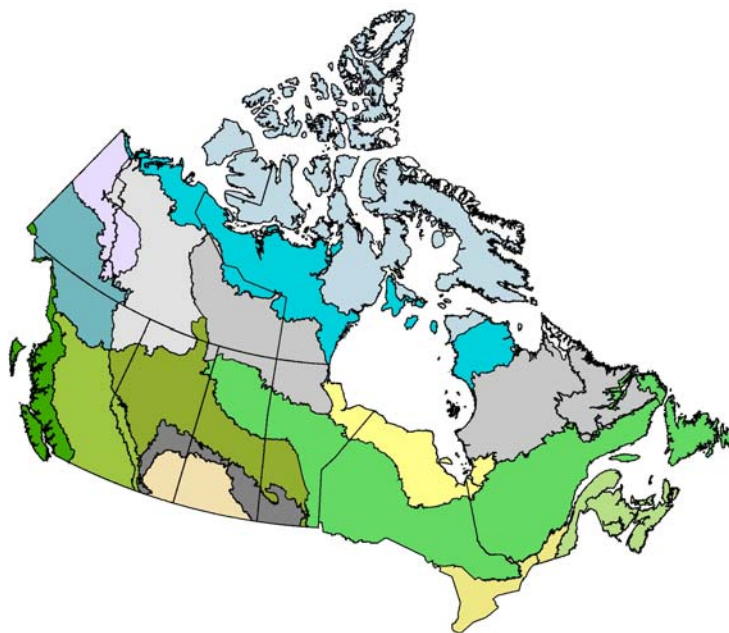




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- Boundaries of land for which Canada proposes to report C change
 - KP Article 3.3 (deforestation, reforestation, and afforestation)
 - KP Article 3.4 (Cropland management, grazing land management, forest management)



Scale – Canadian Approach

- Use ***estimators*** to quantify emissions and removals at scale of specific agricultural activities
- ***Flexibility to use different estimators***
 - Comparative purposes
 - Incorporate better estimators as available
 - Best estimator can change with spatial scale
 - Apply estimators for purposes other than GHG such as water quality, sustainability

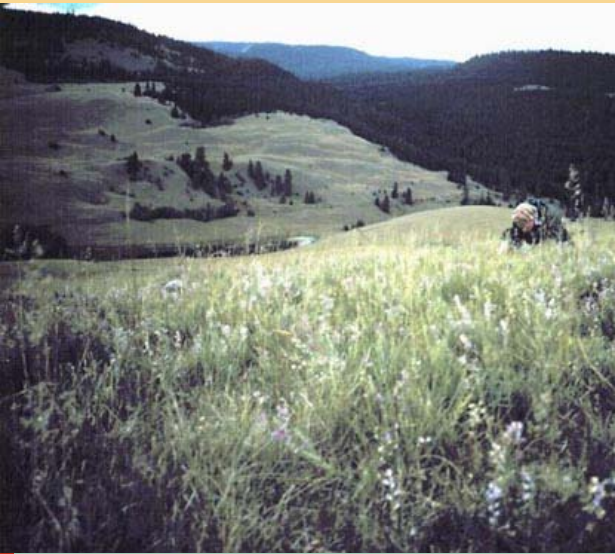
Livestock

- Rearing facilities and manure storage only allocated to SLC polygon
- Animal grazing allocated to cropland (improved pasture) and grassland (“unimproved pasture”)
- Manure application is allocated to toposequences of soil components as part of cropland management



NCGAVS

- Incremental funding from Environment Canada who has national mandate for GHG accounting
 - Part of national GHG accounts
 - Close coordination essential with many government agencies for C accounting aspects
 - Land use classification, land-use change identification, data exchange



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