

Carbon Change from Cropland and Grazing Land Management – Implementation for Canada

Brian McConkey*, Marie Boehm, and Tim Martin
Agriculture and Agri-Food Canada

*mcconkeyb@agr.gc.ca



LULUCF Workshop
Graz Austria



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Canada

Outline

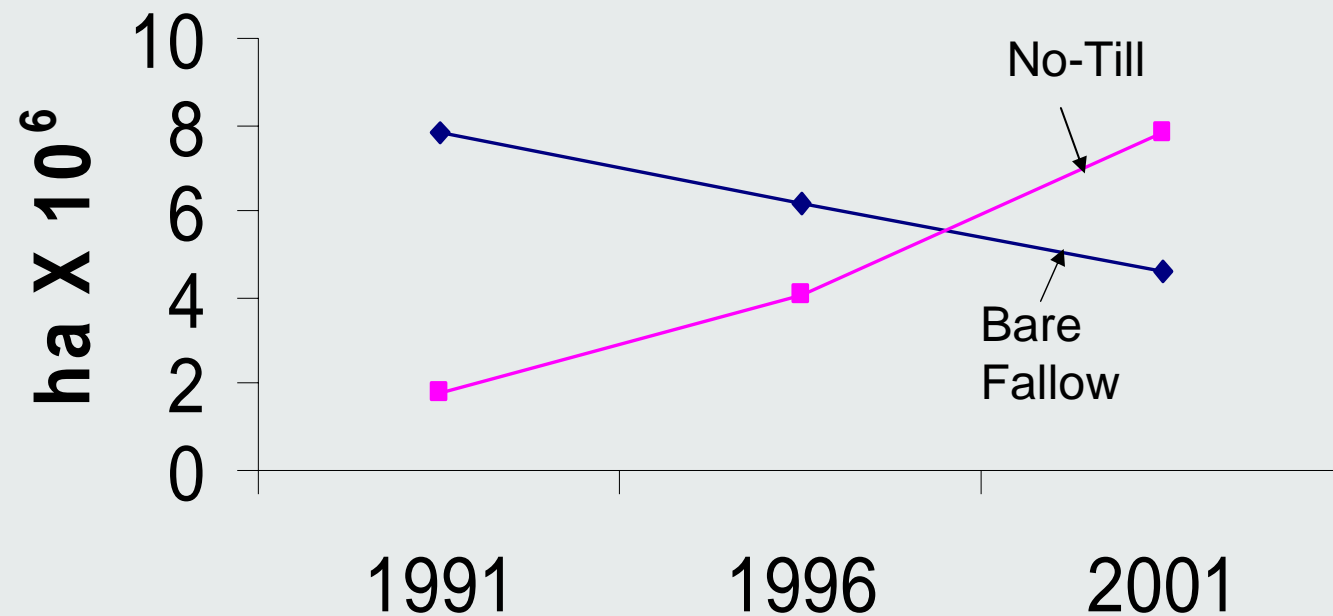
- Election Decisions
- Implementation



Decision questions

1. Is cropland and grazing land management a net carbon sink relative to 1990?

Yes, due to change in cropping practices



Other Changes for Increasing C stocks

- Increasing animal herd
 - Land formerly used for growing for export now producing for livestock so more animal manures applied
 - Increase in pasture and forage area



2. Importance of Histosols?

Less than 0.1% of Canadian cropland is drained histosols

- Relatively unimportant
- C change on mineral soils predominates
- (Question – what to do with potential C change on undrained histosols that are cropped opportunistically when naturally dry?)



3. Political Interest?

- Low and declining soil carbon in western prairies (majority of agricultural land in Canada) has been long-term scientific concern

No agricultural country has ever prospered for more than a generation or two that has not made provision for maintaining the nitrogen and organic matter content of the soil.

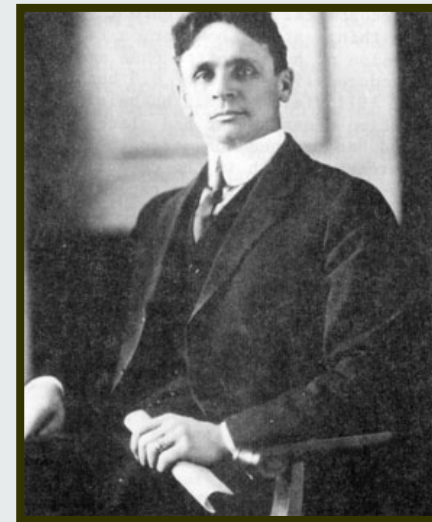


Photo – Henry Janzen

**John Bracken. 1920
Professor, Univ. Sask.**

Decision – Political Interest?

Government report “Soil at Risk” (1984) identified reversing soil organic matter decline (along with reducing erosion and salinization) on prairies as priority

- Initiated Government programming in research and technology to encourage use of agricultural practices that increase soil organic matter
- Ongoing national commitment to soil quality
- Government policy to monitor soil organic carbon status outside of GHG reasons

- Farmers are relatively knowledgeable about soil carbon and have demanded opportunity to have their increasing soil carbon rewarded for its GHG benefits



4. Risks?

- Change in management practices that will cause losses
 - Reason for adopting all C sequestration practices and combination of soil conservation and economics
 - Change in farm economic conditions could reverse
 - General laissez-faire government policy regarding agriculture but growing political acceptance for paying for environmental services
- Future climate change affecting C stocks
 - Risk not large if continue C sequestering practices
 - Risk great if climate change cause reduction in use of C sequestering practices
 - Future factoring out of indirect effects of climate change important to Canada

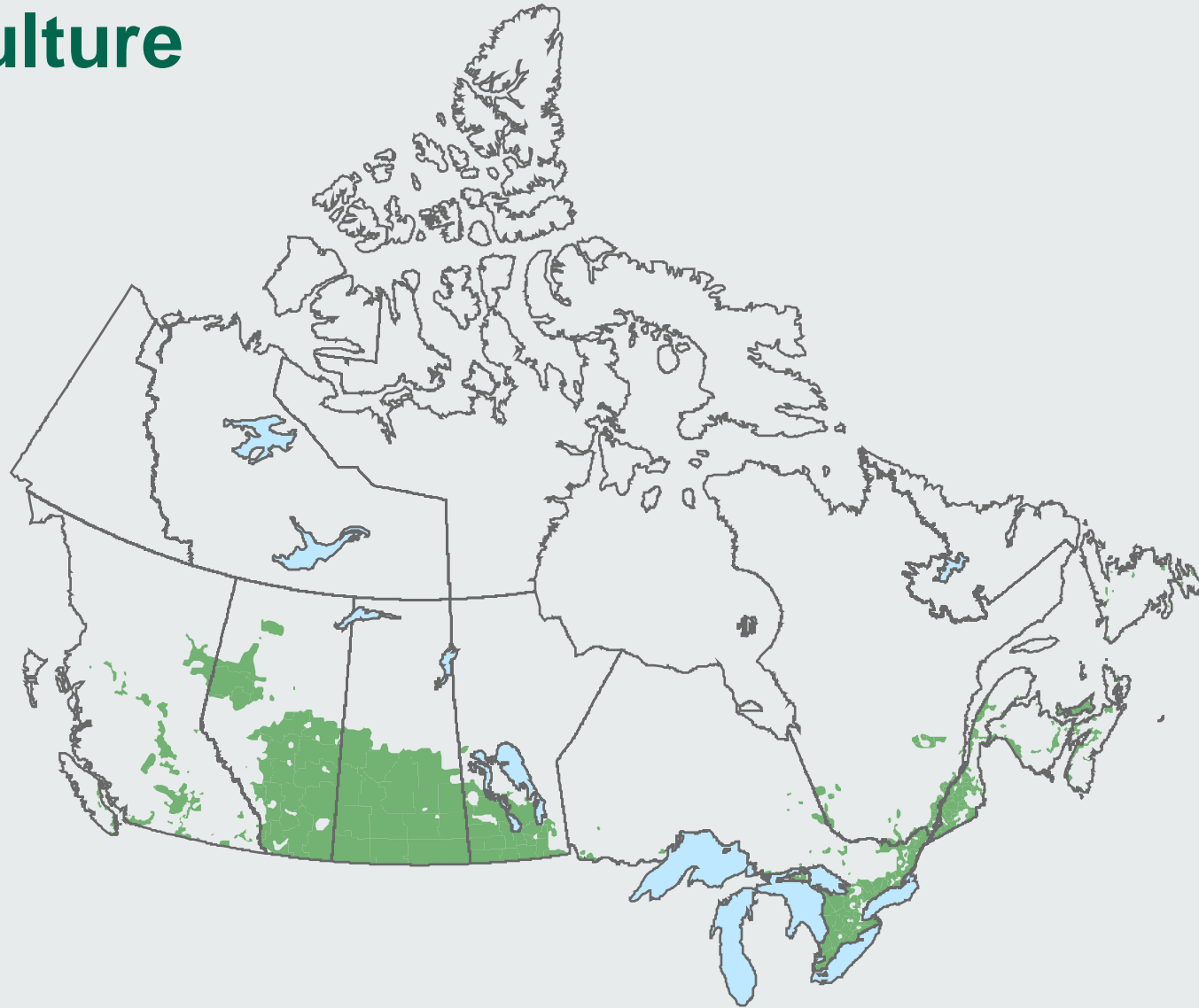
Decision

- For several reasons for Canada plans to elect cropland management (CLM) and grazing land management (GLM) under Article 3.4 of Kyoto Protocol

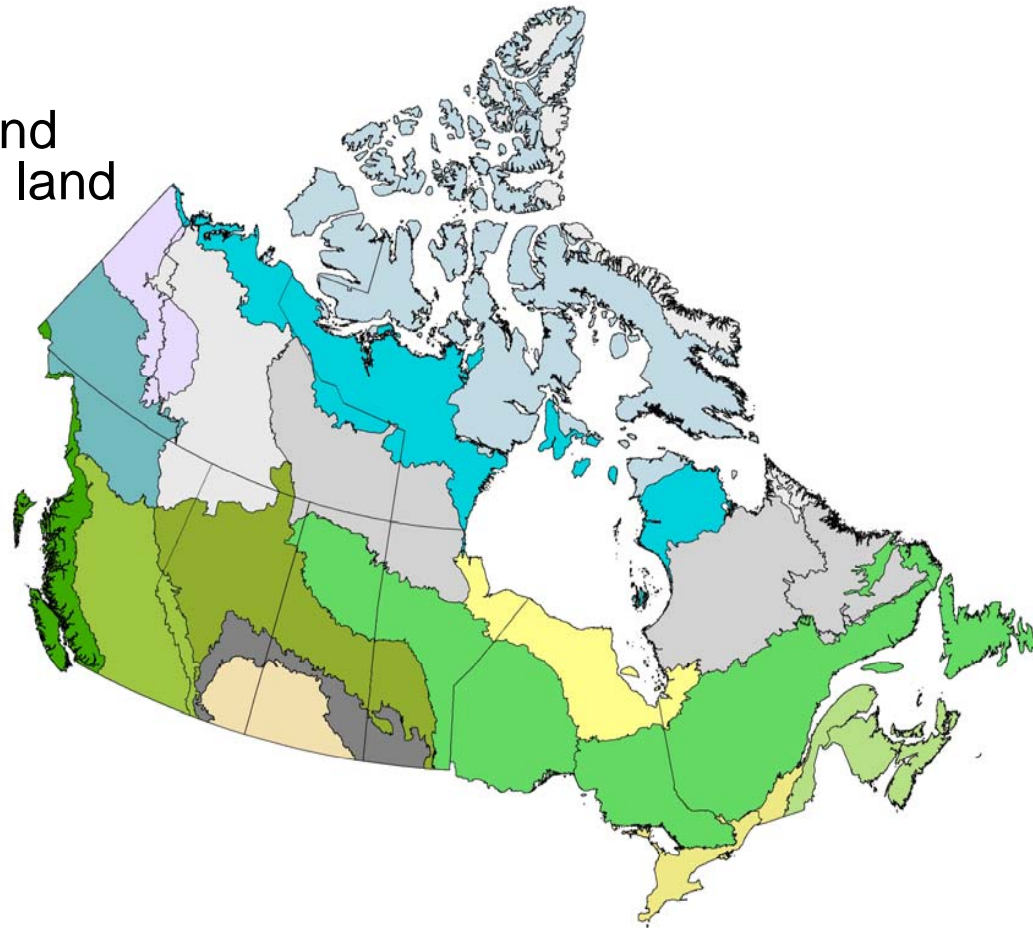
Implementation



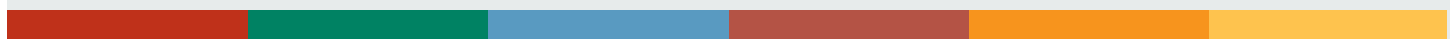
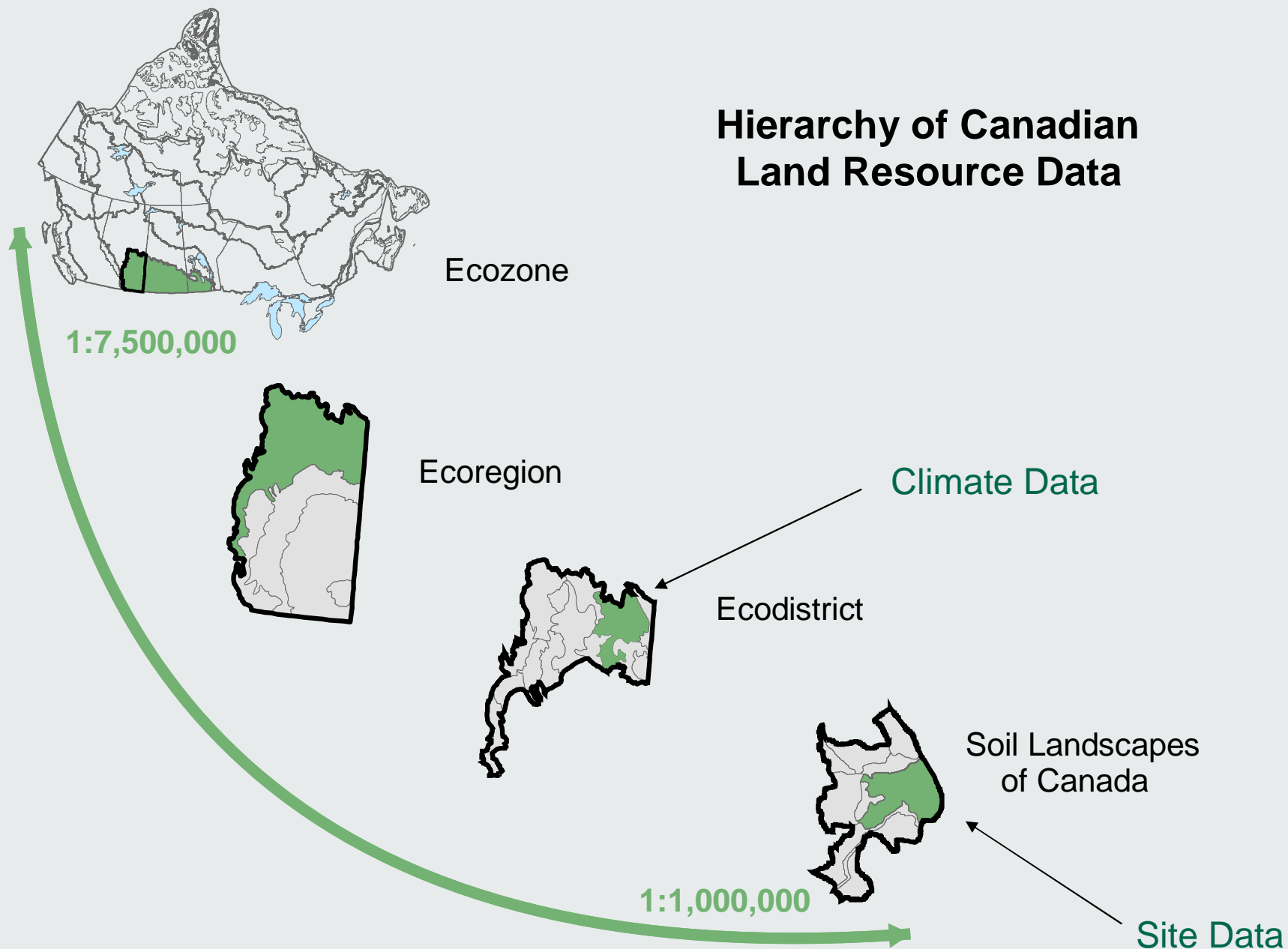
7% of Canadian Land Mass is used for Agriculture



- Reporting Units for which Canada will report C change due to land use, land-use change and forestry (LULUCF)
 - KP Article 3.3 (deforestation, reforestation, and afforestation)
 - KP Article 3.4 (Cropland management, grazing land management, forest management)
- Combination of ecological and provincial/territorial boundaries
- 22 reporting units have significant agriculture



Hierarchy of Canadian Land Resource Data



Analysis Unit

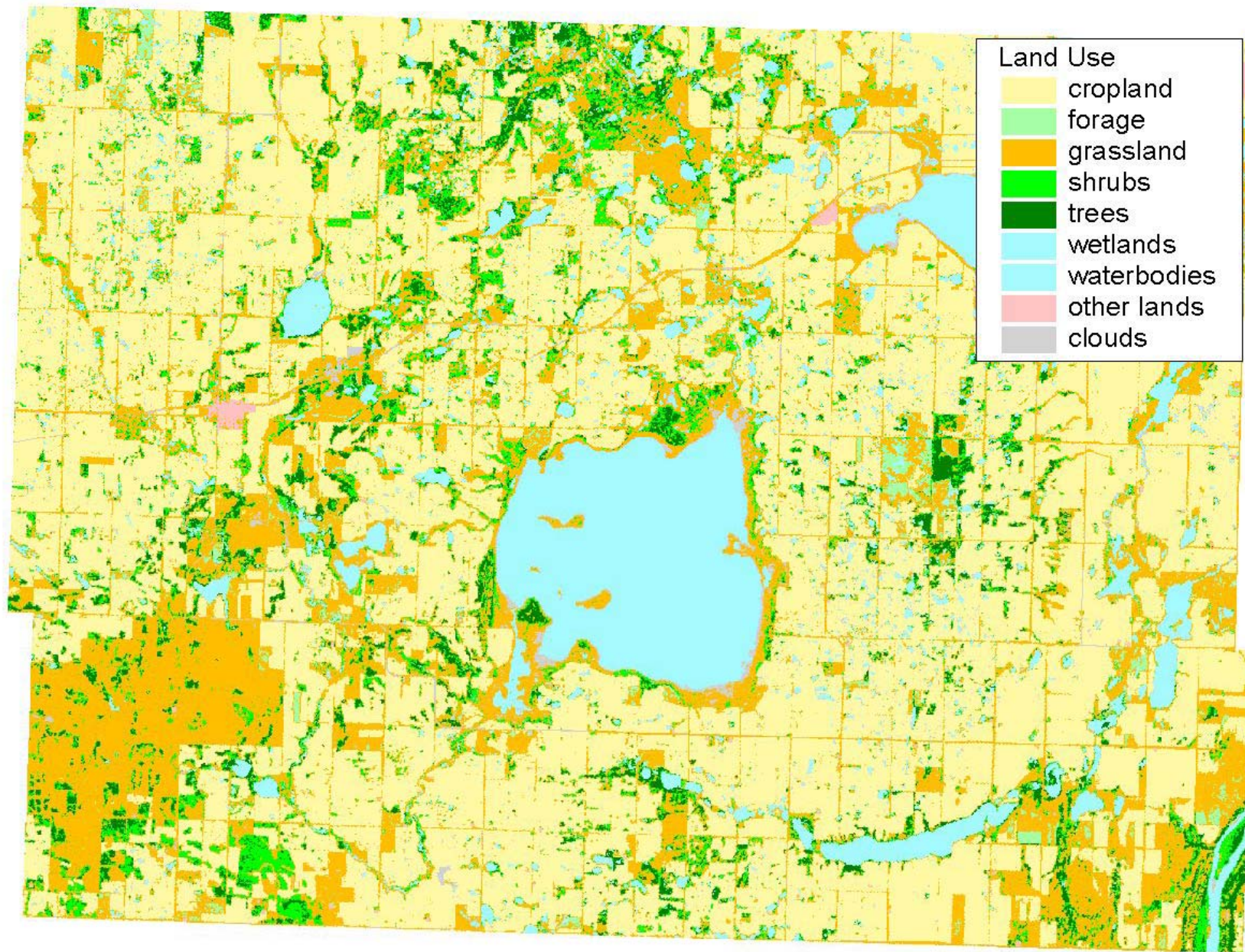
- The analysis unit for agriculture will be the Soil Landscapes of Canada (SLC) polygon
 - 10^3 to 10^5 ha
 - Appropriate at 1:1 M scale
 - 4000 SLC polygons with agriculture



Implementation Issues: Separating Land Uses

- Infer land use from land cover and other spatial information
 - Apply consistently without overlap or omission





Grazing Land - Cropland

- Define KP grazing land = FCCC grassland
 - Grazing land = native grassland and naturalized grassland
 - Permanent grassland
- LUC from either grassland to cropland or from cropland to grassland will be relatively rare
 - Assume no LUC from cropland to grassland although after many decades cropland can become “naturalized” grassland
 - When in doubt agricultural land will be cropland



3.4 Implications

- Problem of separating cropland and grazing land requires both CLM and GLM be elected
- Poor information on management of permanent grazing land but no reason to suggest it is a C source

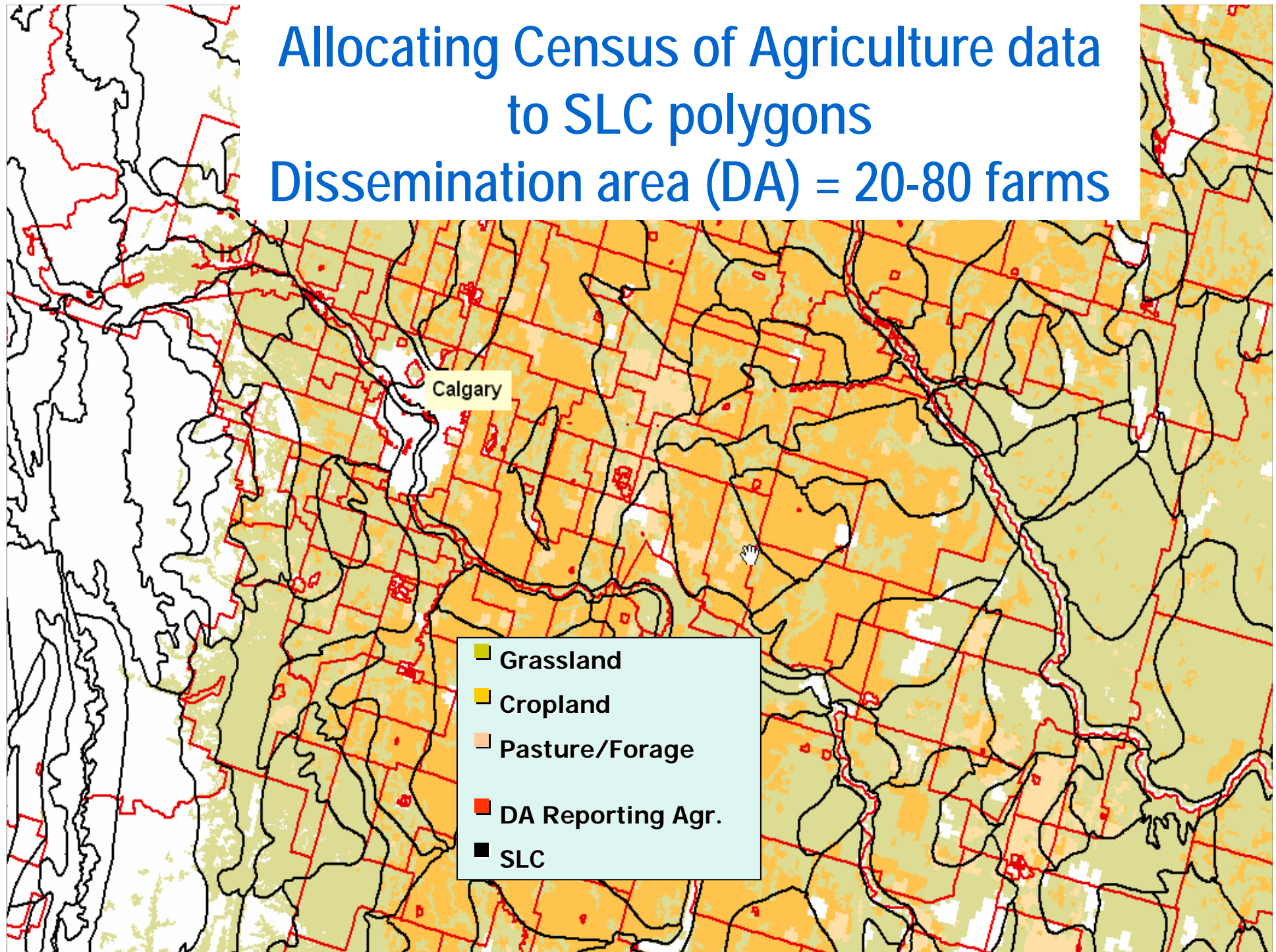


Additional Source of Information

- Census of Agriculture
 - Statistics Canada (responsible Ministry)
 - 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

Allocating Census of Agriculture data to SLC polygons

Dissemination area (DA) = 20-80 farms



Issues – Land Use

- If meets definition of forest it is a forest except selected intensely annually managed tree cover that is cropland
 - Tree fruit orchards, Christmas tree farms, tree nurseries
 - Report C stock changes under CLM
- Define forest cover that have extensive and occasional grazing as forest
 - No C stock changes from grazing of forest reported
 - (CH₄ and N₂O emissions from that grazing reported under agriculture)

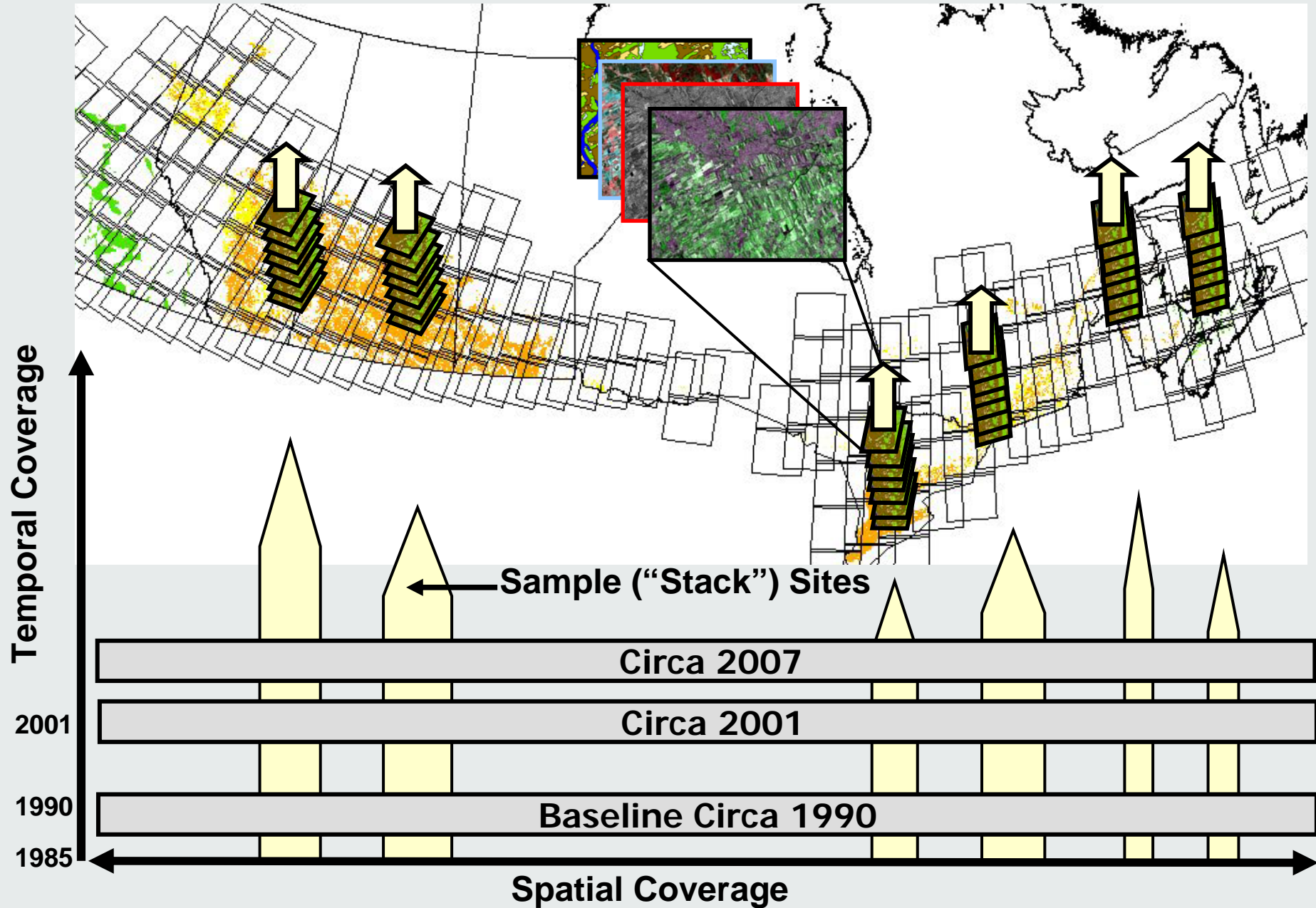


Earth Observation

- Intensely study over time selected areas that are representative of agriculture based on overall agricultural activity from Census of Agriculture
- Identify LUC and some land management changes for this intense study
- Extend information from study areas to other areas of similar agricultural activities



Land Use Earth Observation Approach



LUC

- Recognize that area of any land use in Canada will always have some uncertainty
- Uncertainty in LU area implies unknown LUC but LUC relatively rare so most of this implied uncertainty comes from methods to identify LU at different times
- Develop LUC area as certain for each report
 - Inventory needs to be able to accommodate and correct for misclassification once discovered
- Will know LUC on gross area basis
 - Most problematic for grassland <-> cropland



C stock issue

- Live biomass and dead organic matter pools
 - There can be important increases and decreases in these pools where cropland and grazing land management involves changes in woody vegetation and debris
 - No evidence that are a source
 - Quantification difficult because diverse and heterogeneous
 - Minimum forest width is issue



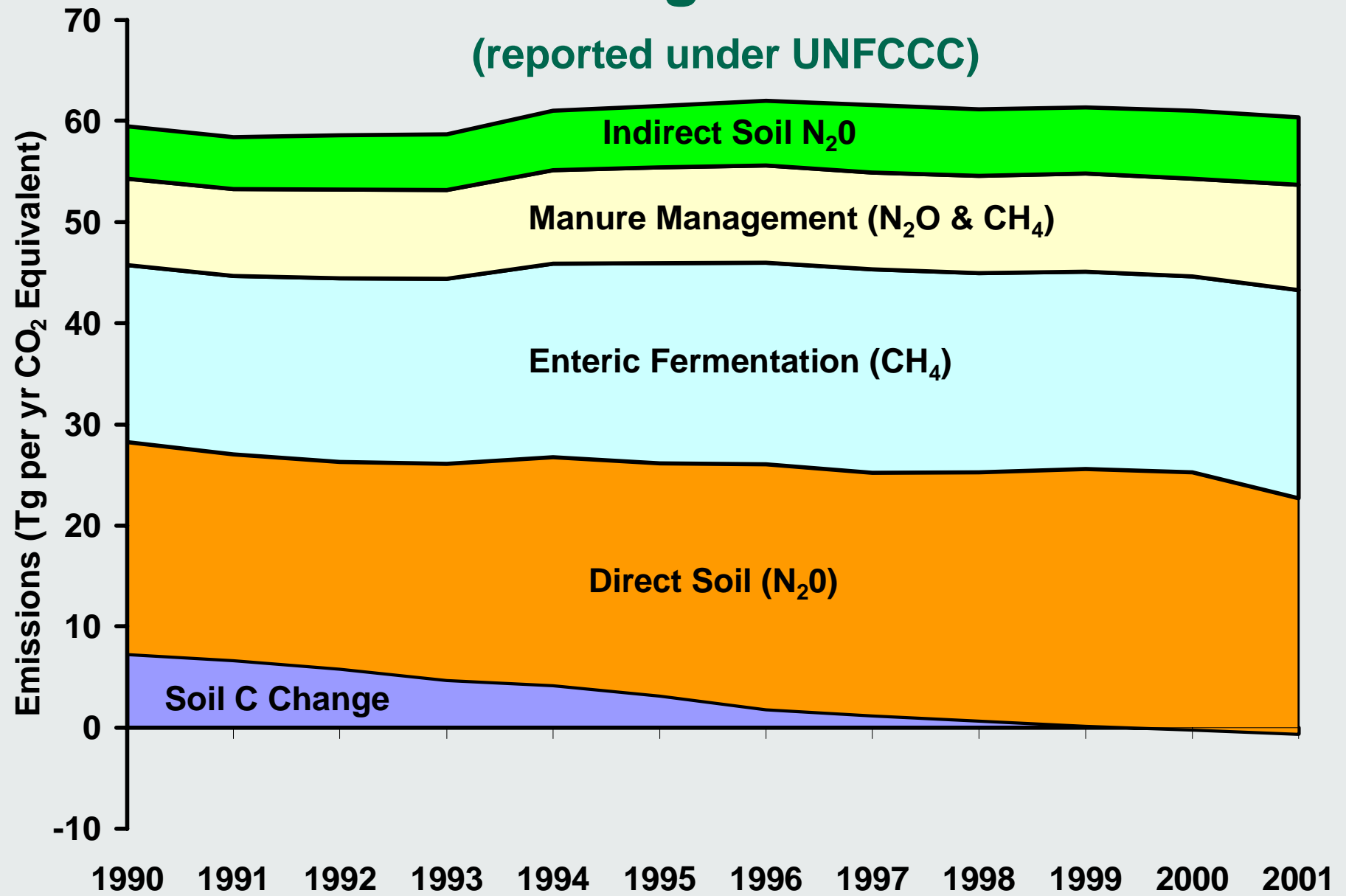
Implementation

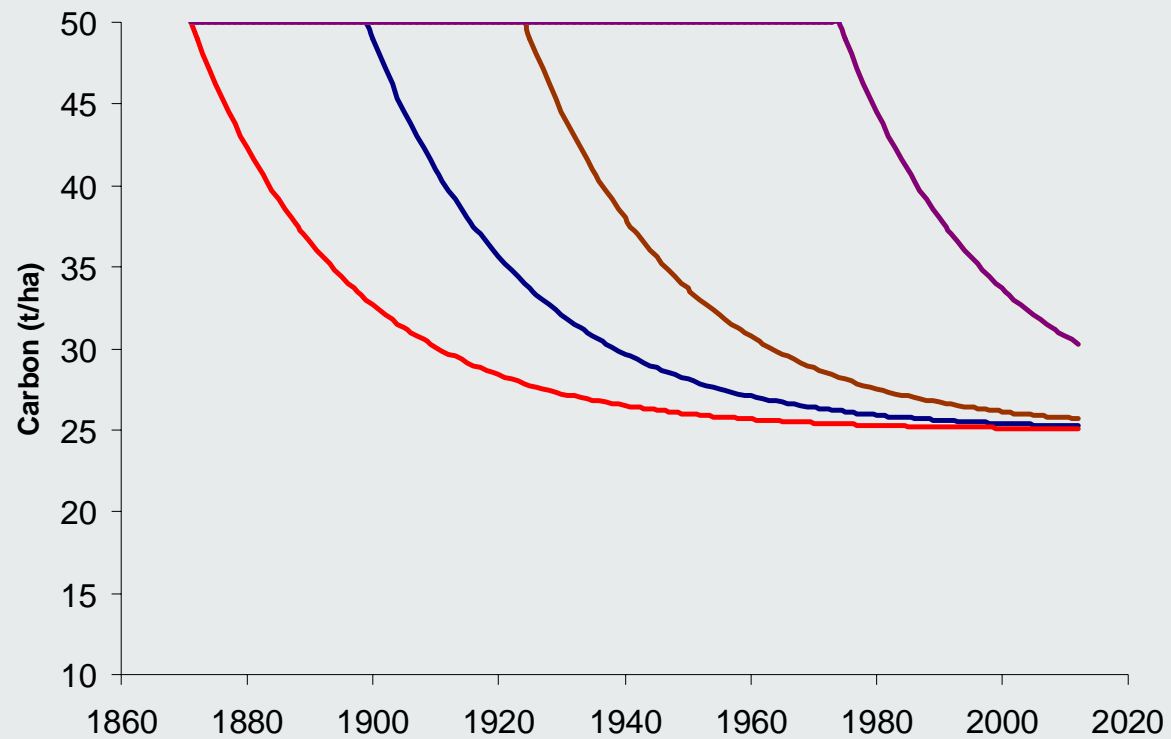
- C change in 1990
- Past and current FCCC reporting has been based on estimates of organic C change as a soil quality indicator for policy purposes
 - Good representation of pre-1990 land use and management was not priority



Canada's Agricultural GHG

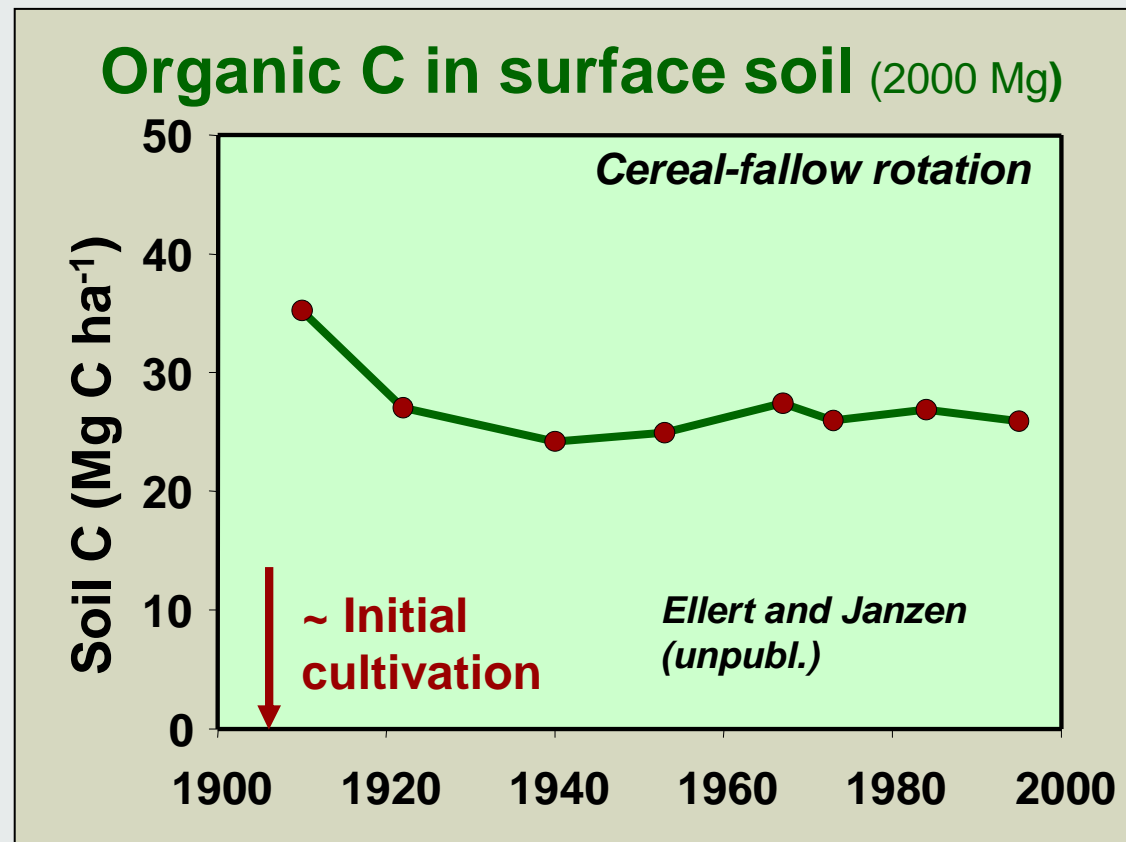
(reported under UNFCCC)





Year of LUC to Agric.	kg C ha ⁻¹ y ⁻¹ in	
	1990	2010
1871	8	4
1900	25	11
1925	70	31
1975	540	240

- Majority of Canada's agricultural land converted from native vegetation from 1880-1980
- However small change in soil C, especially difference between C stock change in 1990 and later, will be difficult to detect



**More carefully include LUC and management
within 40 yr on C change in 1990**



Current deforestation to increase agricultural land



Implementation – Management Changes

- Land Management Changes
 - Management within land use
- Management changes identified from Census of Agriculture and various annual surveys
 - Spatially referenced
- Only know net area of changes to individual managements
 - Don't know combinations of changes to management
 - Don't know how management combines with LUC
 - Land can be entering and leaving practices concurrently

Basic Approach

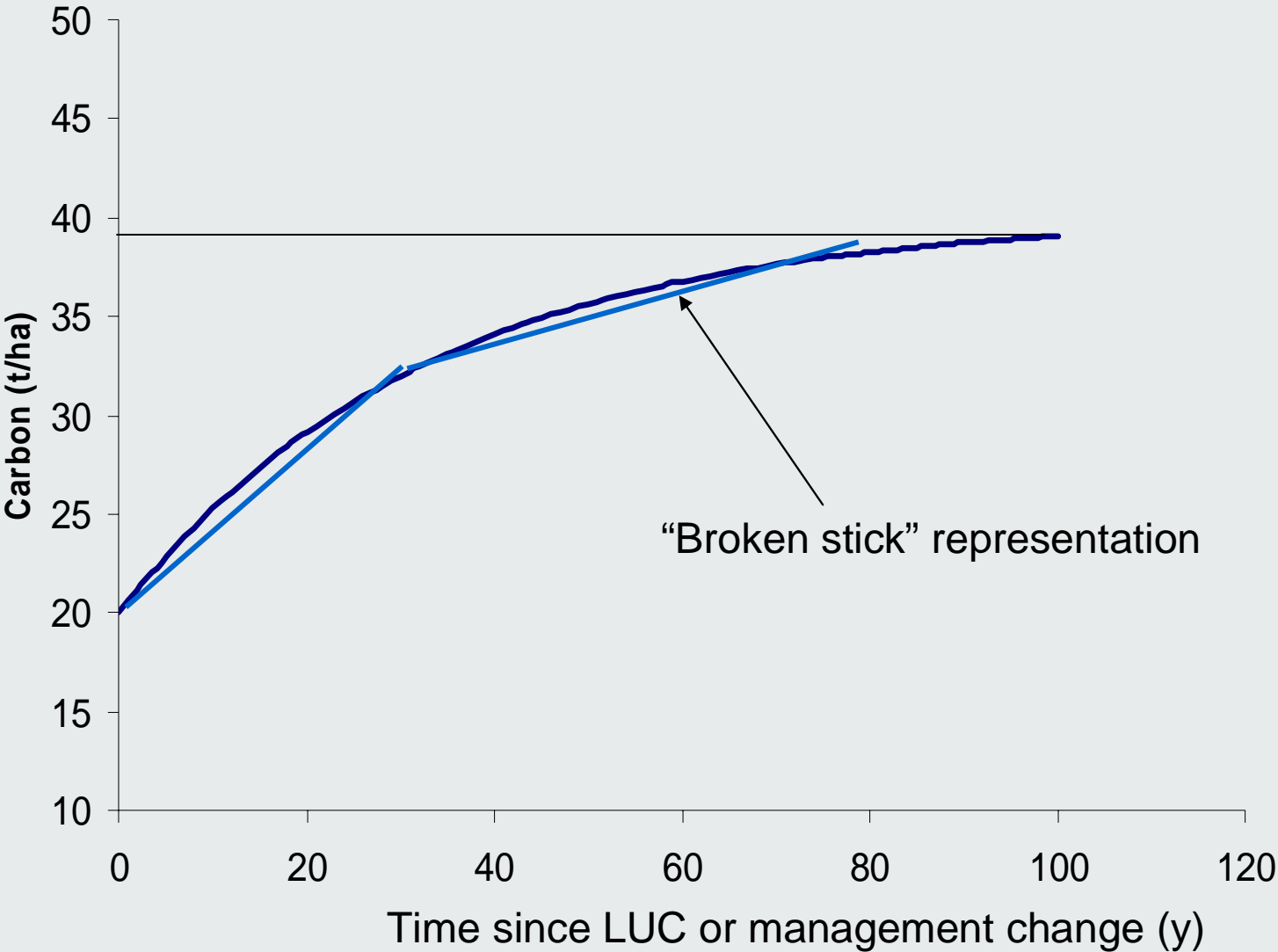
- $C \text{ change} = \textit{Activity} \times \textit{Emission/Removal Factor}$
 - Where *Activity* is a LUC or management change
 - *Emission/Removal Factor* is change in C stocks per unit area of that activity
- For LUC, know gross area of change, so factor depends on time and direction
- Due to limitation from only knowing net area of change, we must assume C change from entering and leaving a practice are equal in magnitude but opposite in direction
 - Loss for dropping practice same as gain from adopting practice
 - Agrees with empirical data for land management changes after long time in one management

Model to produce *E/R Factor*

- Derive *E/R Factor* using validated Century model (DayCent)
 - Model results with and without change in practice
 - Difference per unit of change in practice is the *Factor*
 - Not include effects of particular annual weather
- Advantages of Approach
 - Largely removes effect of imprecise initialization of soil state
 - *E/R Factor* derived for mix of crops and practices on cropland



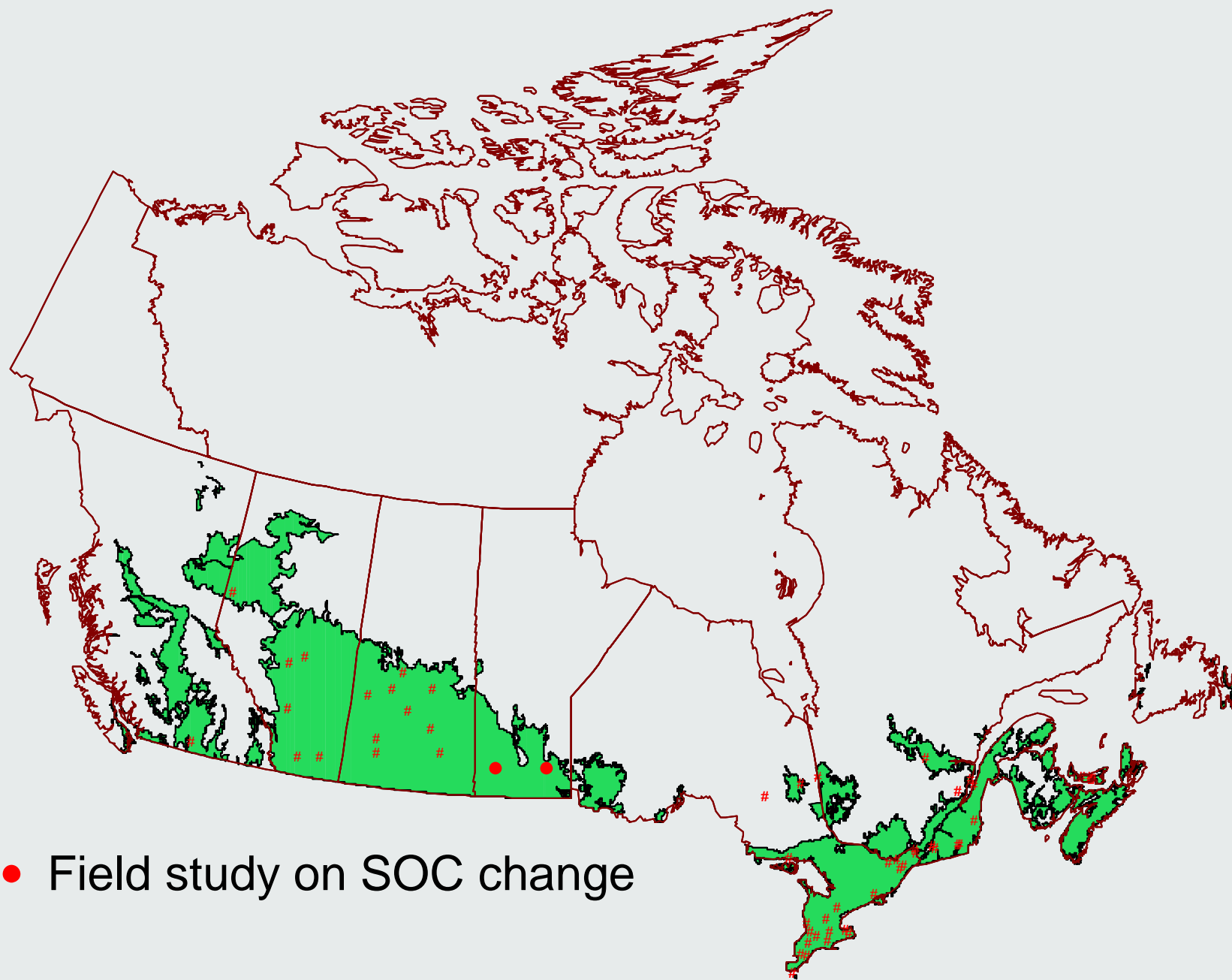
Factors



Combining C stock changes from combined management changes and/or combination of management change with LUC

- Must assume that factors can be added together
 - Experimental evidence suggests little interaction of combinations in management changes on C stock after long time
 - Little experimental evidence for management changes combined with LUC
 - Relatively small area
- Effects of assuming additivity of factors and reversibility is included in factor uncertainty
 - Lower factor mean value and increase variability





- Field study on SOC change

N₂O and CH₄

- Bigger research priority of Canada than C stock changes from LULUCF
- Need to add N₂O emission from summerfallow
 - Reduce some gains in emissions for elimination of summerfallow
- Will include N from LULUCF (soil organic C) loss as source of N for N₂O emission
 - 3.1 vs 3.4 accounting?

N₂O and CH₄ (continued)

- Where no-till being adopted empirical (and model-estimated) N₂O emission decrease
 - Highly uncertain so not decided as whether to report this no-till effect
- Increased N₂O and CH₄ emissions from more livestock including their manure has to be reported

Summary

- Canada considering election of CLM and GLM under 3.4
- Part of flexible MARS tool for whole landscape
- Aim for system that is as detailed as necessary but maintains transparency
 - Drill down capability
- Questions
 - Grassland – cropland separation and effects of uncertainty in entire LU identification?
 - 1990?
 - Accounting for management changes when only know net area of change?



Canada 

