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# Measurement and quantification of C stock changes in grasslands

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Canada

# Background

- Pressure from market for sustainable beef
  - Grasslands are important part of sustainability story regarding climate change, biodiversity, water quality, soil quality, etc.
- Grassland are important to GHG but not fully included
  - Canada does not estimate C stock changes on grassland due to lack of information on management and status of changes
  - Net total of Canadian agricultural sinks and sources was roughly constant from 1990 to 2011 but are now increasing due to declining sink and increasing emissions
    - Beef production represents about ½ of GHG emissions for agriculture for Canada and most of that for production of feeder animals
  - Offset quantification for grassland complex because need to include other affected GHG emissions

# Challenge

- Develop science narrative regarding grasslands that engages non-scientist decision makers to bring environmental effects of grassland management into public and private policy
  - No surprises (predictable)
  - Quantifiable (science widely accepted)
  - Broadly supported (acceptable outcomes across stakeholders)
  - Implementable (practical, low-cost, low maintenance)

# Outline – C status of grasslands

1. GHG Inventory
2. Guidance for measuring C change on grasslands
3. Issues measuring C change

# GHG Inventory

- Grassland is one of 6 land-use categories for inventory
- What is grassland?
  - Native grassland (how much, where?)
  - Naturalized grassland land (how much, when, where?)
  - Tame pasture and forages?
  - Treed pasture versus pastured forest?
  - Grassland grazed by domestic livestock?
- How much land-use change (LUC)?
  - To what and from what land-use?
- What is C stock change?
  - Grassland remaining grassland?
  - LUC to grassland?
  - LUC from grassland?

# Inventory

- Previous definition for Canadian inventory (natural land used for grazing on Brown and Dark Brown soils) designed for simplicity and minimize need to identify LUC
  - Not good definition
  - Missed at least 8.2 M ha that were widely considered “grassland” by agricultural industry
- Areas of perennial herbaceous area becoming better quantified with earth observation based products
  - But this capability has created new problems of splitting the area into land uses and identifying LUC for inventory purposes
- Include $CH_4$ uptake?
  - Involvement with IPCC
  - Need values as affected by human management
  - Could Canada go on its own?

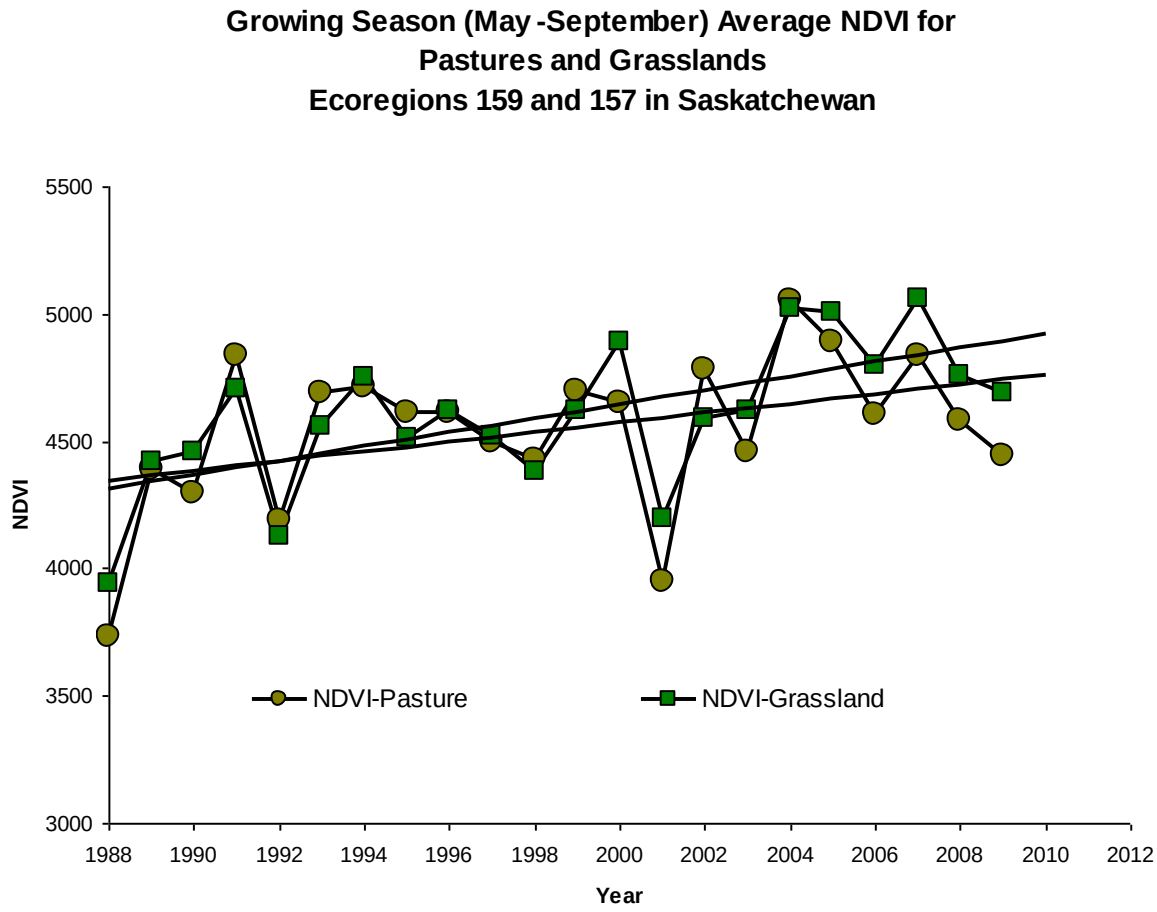
# Grassland remaining grassland – C stock Change

- Undertaken meta-analysis for Northern Great Plains comparing C and N status of grazed and ungrazed native range
  - 52 studies found
- Average C change of 0.16 Mg $ha^{-1}$ $yr^{-1}$ relative to ungrazed
  - More in soil (<15cm) and less in litter
  - Clear effect of grazing but not grazing regime (light, moderate, heavy)
- Tighter N cycling with grazing
  - Average N increase of 6 kg $ha^{-1}$ $yr^{-1}$ relative to ungrazed
- What is happening to ungrazed?
  - NEE (3 studies) suggests ungrazed a slight sink (C sink in moderate to wet years and C source in dry years)
  - Little C-N change most coherent with estimated N additions

*Wang, X. et al. in preparation*

# Use of proxy data to estimate C change

- E.g. Normalized Difference Vegetation Index (NDVI)




*Li et al. 2013*

# Guidance for measurement of C on grassland

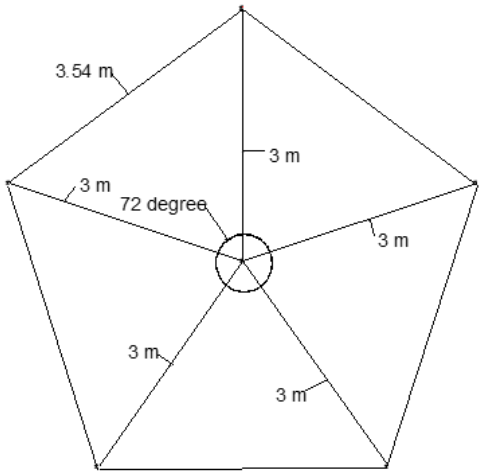
- Canada is charter member of the Global Research Alliance on Greenhouse Gases now having 45 member countries
  - Identified by many countries that existing guidance on measuring C stocks in grasslands is weak
    - C stock change on permanent grasslands not included in policy because of poor information
  - Grasslands typically have more spatial heterogeneity that croplands due to perennial vegetation community, livestock behaviour or management, and often underlying soil variability than cropland so guidance for measuring C on cropland is not fully appropriate.

# Guidance – Literature Review

- Canada contributing the initial literature review
  - 2000 publications in worldwide literature identified
  - 795 deal with quantifying heterogeneity of C stocks
  - 270 specifically deal with measurement of C stocks of grassland
- Studies from 27 countries
- Most of the publications use classical random sampling strategies
  - 15% of the publications use a geostatistical approach to model or account for structure of heterogeneity
- 30 and 100 cm most common depths (25 and 19%, respectively)
- We will develop typologies of grassland types, sources of variation, measurement objectives, and sampling strategies to analyze the publications and distill knowledge that improves measurement ability

# Measurement

- Continuing interest to converting marginal cropland in Brown soil zone to permanent pasture
  - What are the effects of re-establishing a native mix?
- What is C sequestration from the conversion of cropland to native mix pasture?
  - Using pentagonal microsites to evaluate C change over time



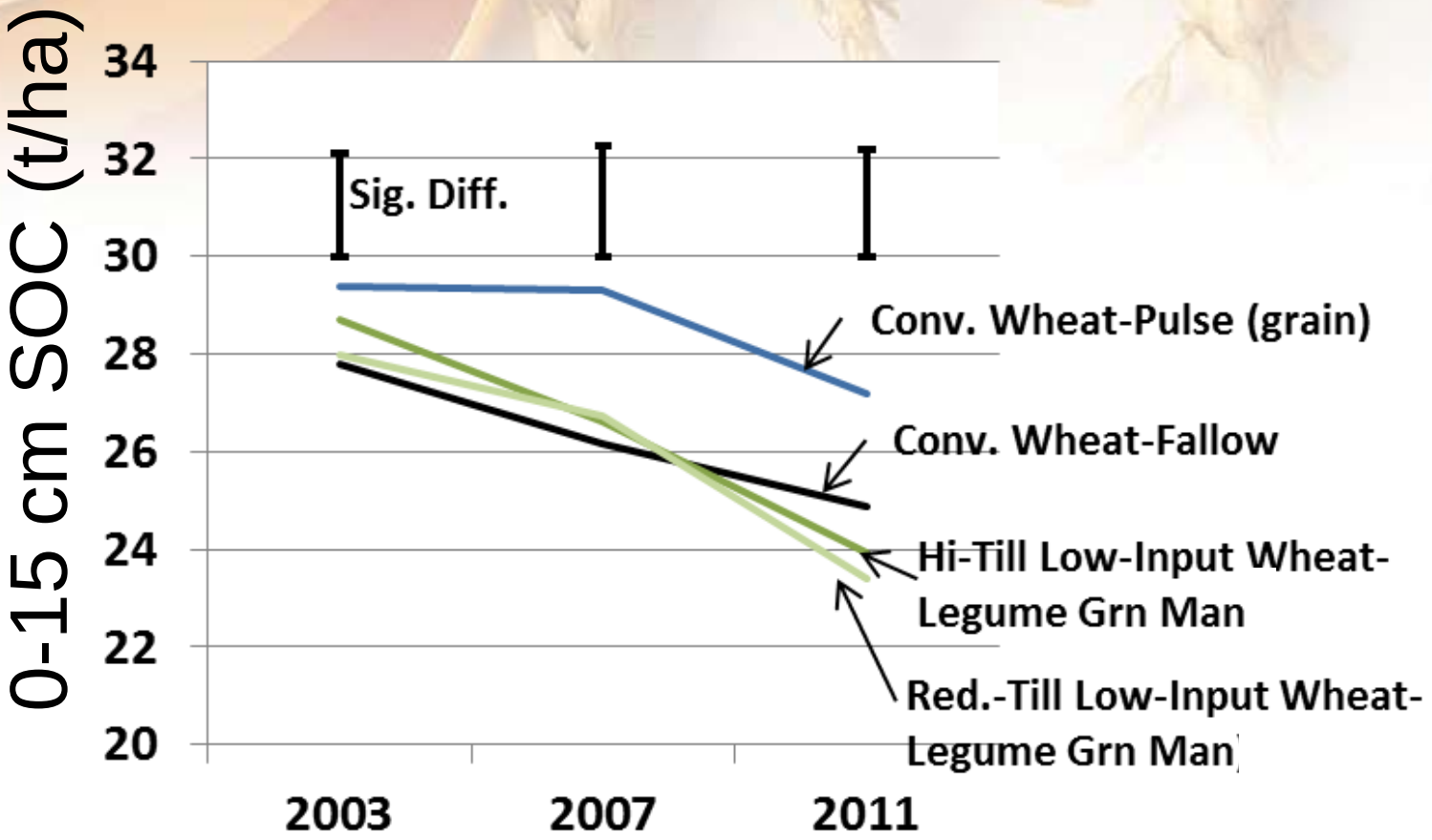
# Effect of Re-establishment of a Native Mix

- Sixteen pastures (2 ha ea.) involving two native mixtures [7 species simple (S) or 14 species complex (C)] seeded in spring 2001 on long-term cropland
  - In each pasture a permanent enclosure (3.6 x 3.6 m) was used as the non-grazing treatment.
  - From 2002 to 2004 there were four replicates and two grazing utilization levels [low (40-50%) and high (60-70%)].
  - From 2005 to date, there has been two replicates and four grazing regimes based on timing (continuous, spring only, summer only, and fall only).
- C stocks increased for 2000 to 2003 but then remained at about 2000 level for 2008 and 2011 when including C in litter and cowpies
  - What will 2014 samples show?

# Measuring C change

- What is the appropriate measure?
  - What atmosphere sees?
  - **What current human management has accomplished compared to what would have been**?
    - Basis for offset
    - Direct human-induced C change that is key to inventories
- Measurement of C stock change alone is problematic if cannot be tied to management and what would have been

# Soil Organic Carbon – Nearby Cropland



# Summary

- To have grassland C change considered fully in policy and trade we need to estimates that optimize TACCC (transparency, accuracy, completeness, comparability, and consistency)
  - Practical, accepted, low-cost, predictable quantification of full range of management of grassland
  - Lots of challenges remain when looking at problem from policy perspective
    - Area, type, management, LUC, C change from management compared to what have been, etc.
  - Backed by comparable evidence
    - Depth, comparison basis, litter, etc.
  - We need to work together to address these!

# THANK YOU!

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