Managing Greenhouse Gas Emissions from Agro-Ecosystems under a Changing Climate

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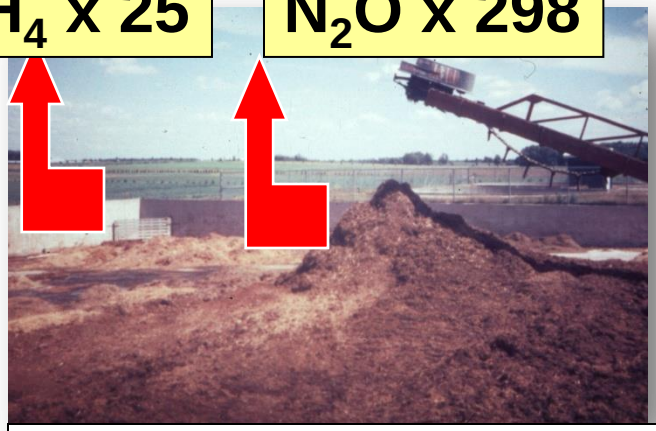
OAC Food Agriculture Communities Environment

Sources of GHG on the Ontario Farm

CH_4 x 25

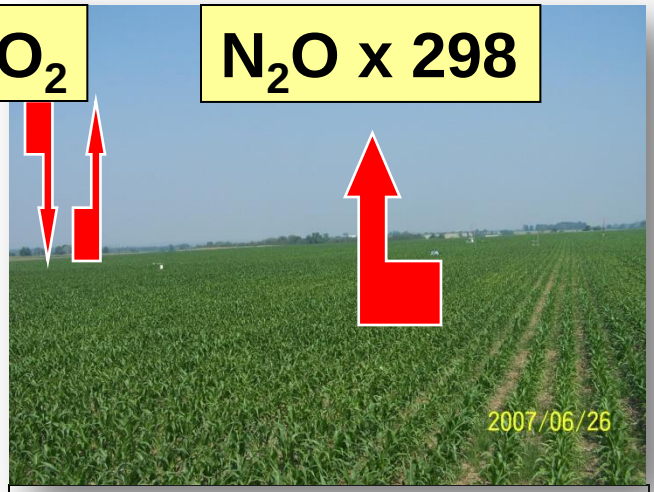
Enteric fermentation: 2.7 Mt CO_2eq

CH_4 x 25 N_2O x 298



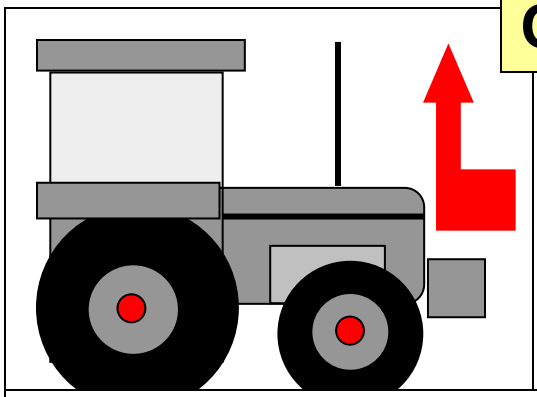
Manure: 1.5 Mt CO_2eq

CO_2 N_2O x 298



Soils: 5.4 Mt CO_2eq

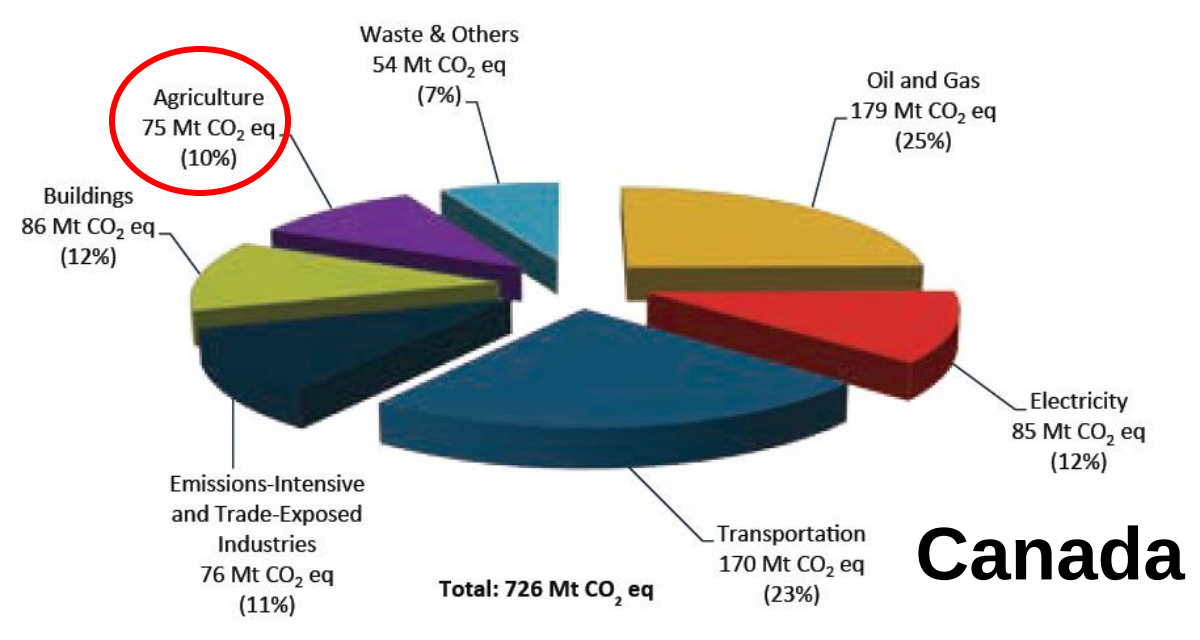
CO_2



Energy: 4 Mt CO_2eq

Source: Environment Canada

Importance of Agricultural GHG Emissions



Land use and land use change:
-15 Mt CO_2eq

CO_2

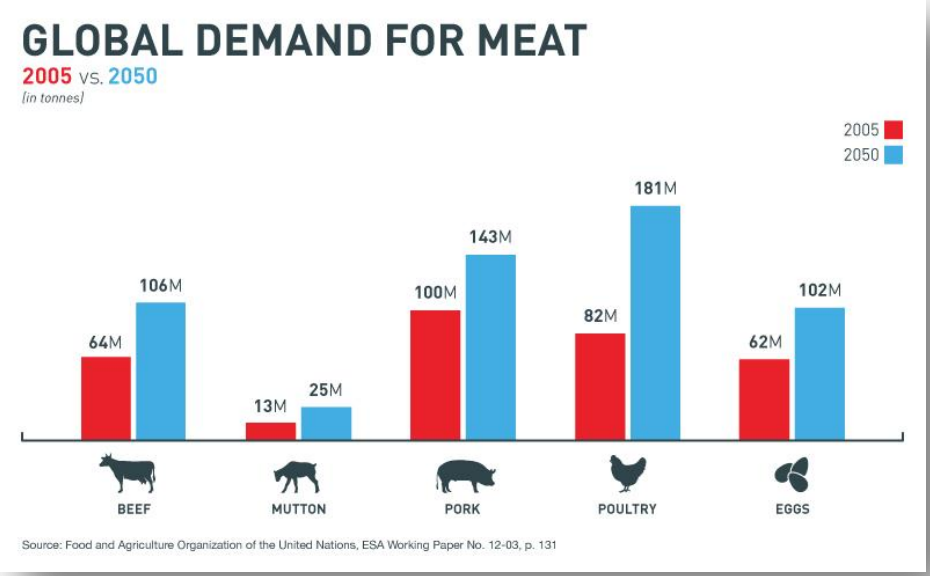
Agriculture:
60% Livestock (enteric fermentation and manure)
40% Crop production (soils)

CH_4 and N_2O

Linked to agricultural production

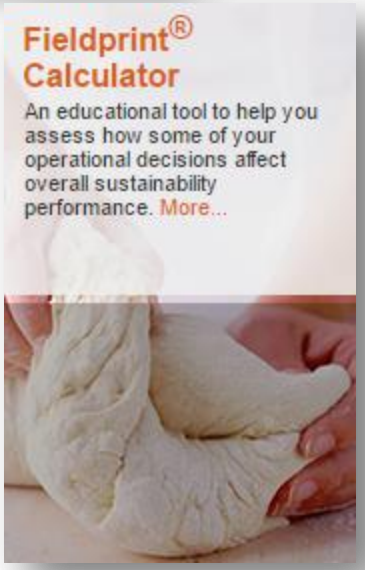
Source: Environment Canada

Should agricultural sector be concerned?



Demand for agricultural products will continue to grow

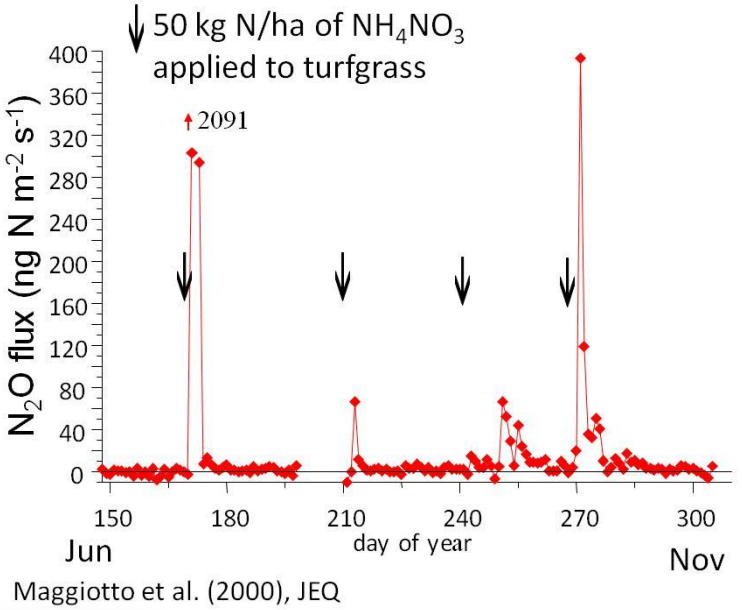
There is increased pressure to evaluate sustainability of agroecosystems through scientifically-based metrics



https://www.fieldtomarket.org/

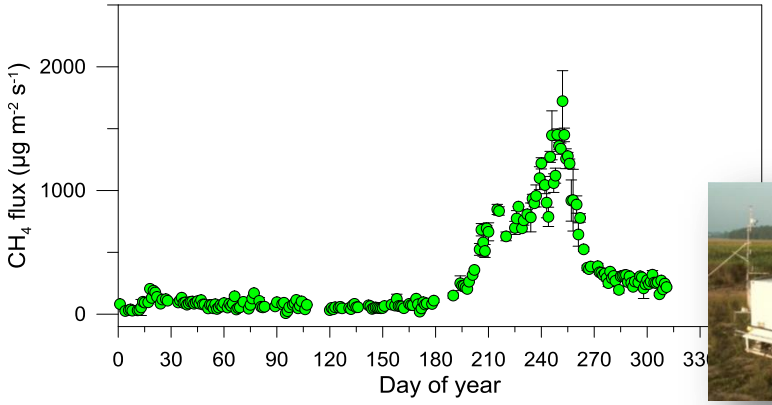
Main sources of GHG emissions

Nitrogen addition enhances nitrous oxide production by nitrification and denitrification in soils



Maggiotto et al. (2000), JEQ

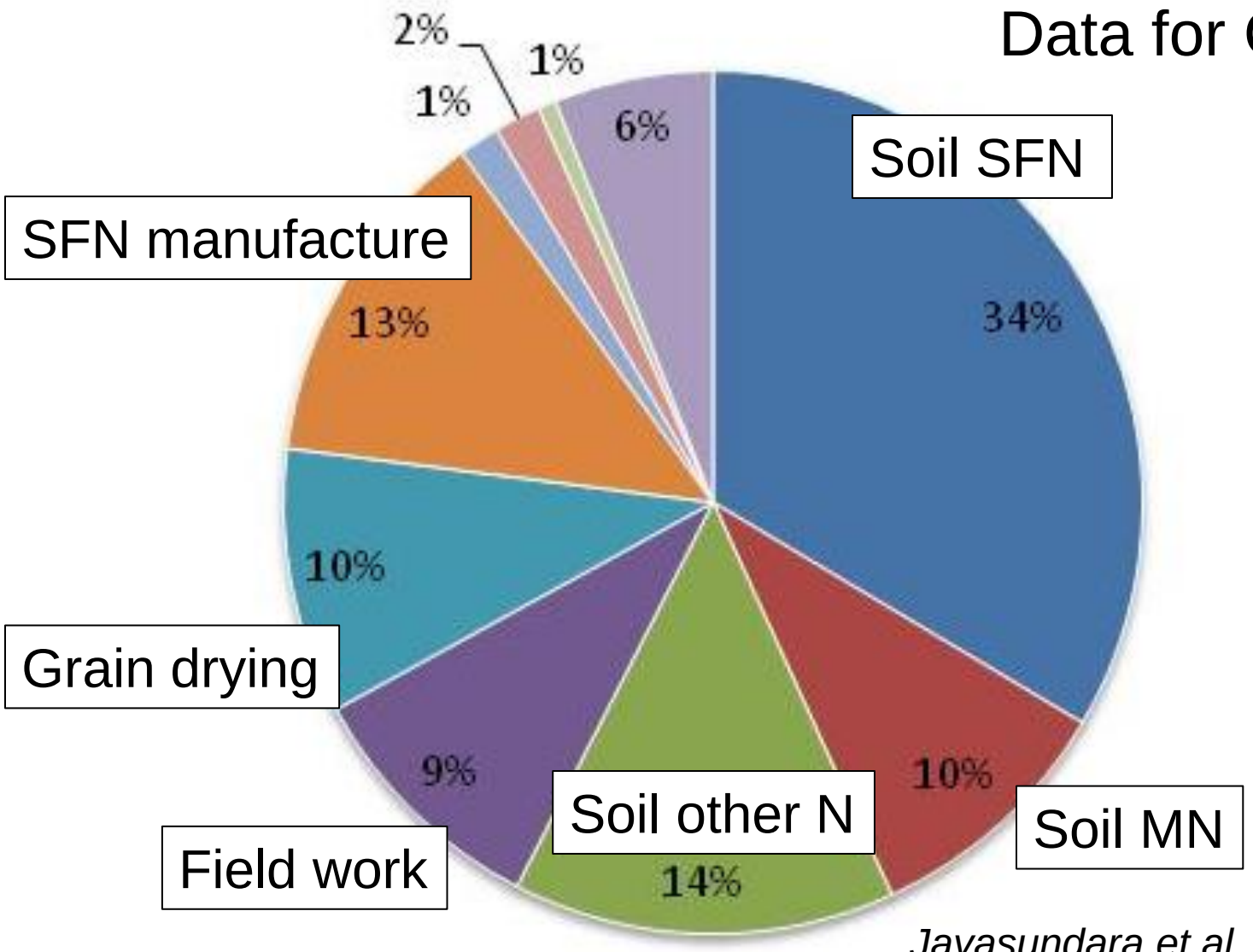
Methane is produced by decomposition of organic matter in anaerobic conditions



How to best manage agro-ecosystems to minimize GHG emissions?

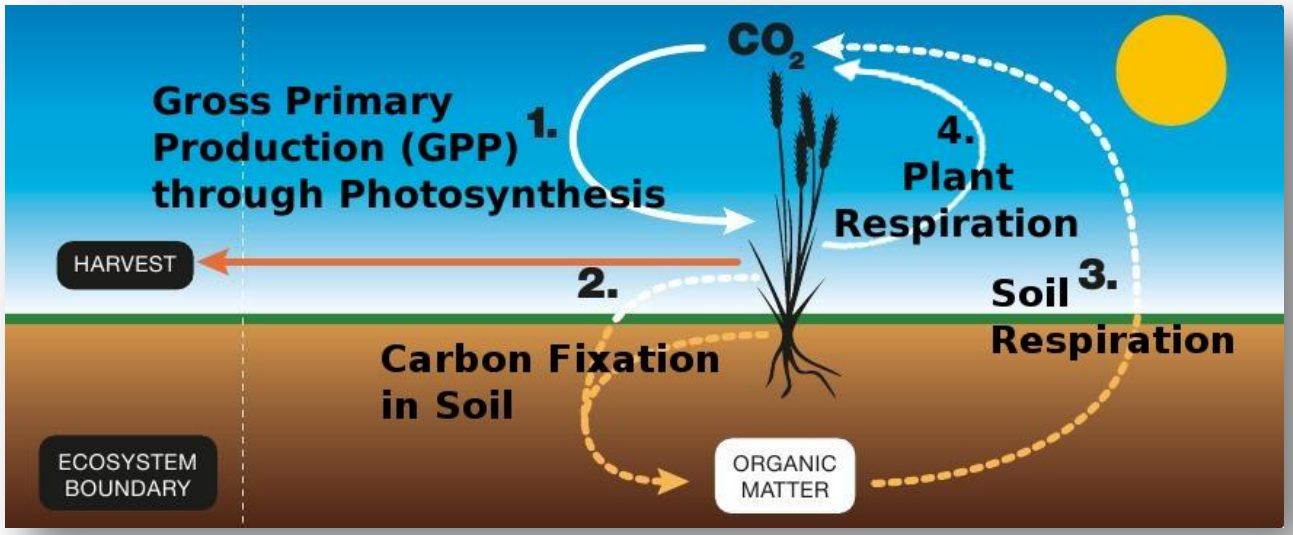
Considering on- and off-farm GHG sources

Data for ON corn



Jayasundara et al. (2014). CJSS

Carbon budget (sink or source?)



Source: Agriculture and Agri-Food Canada

Net Ecosystem C Budget = **Gross Primary Productivity** (gain)
and **C removed** at harvest (loss)
and **Ecosystem Respiration** (loss)

How to best manage agro-ecosystems to increase carbon storage?

Conditions with ↓C storage and ↑GHG emissions

Degraded or marginal land

http://www.omafra.gov.on.ca/

Bare soil and low residue return

Intensive tillage

http://www.country-guide.ca/

Drained wetlands

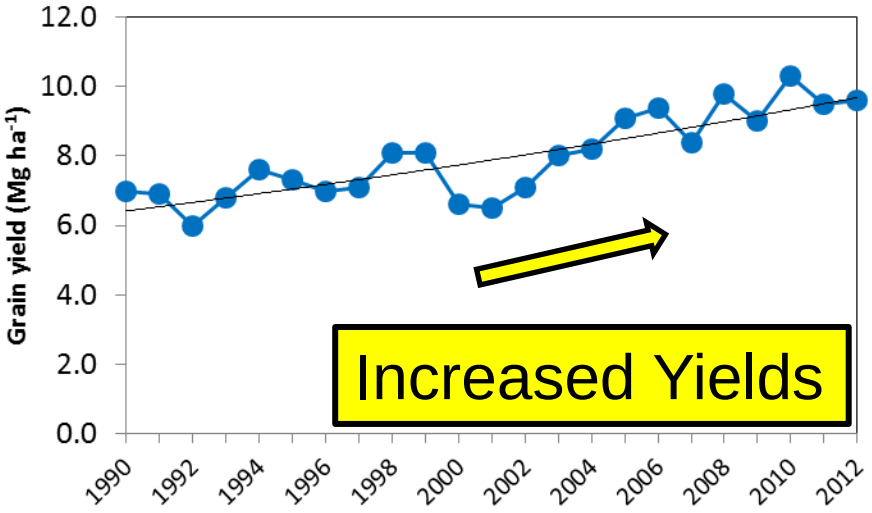
http://www.waterloochronicle.ca/

Manure storage

Inefficient nitrogen use

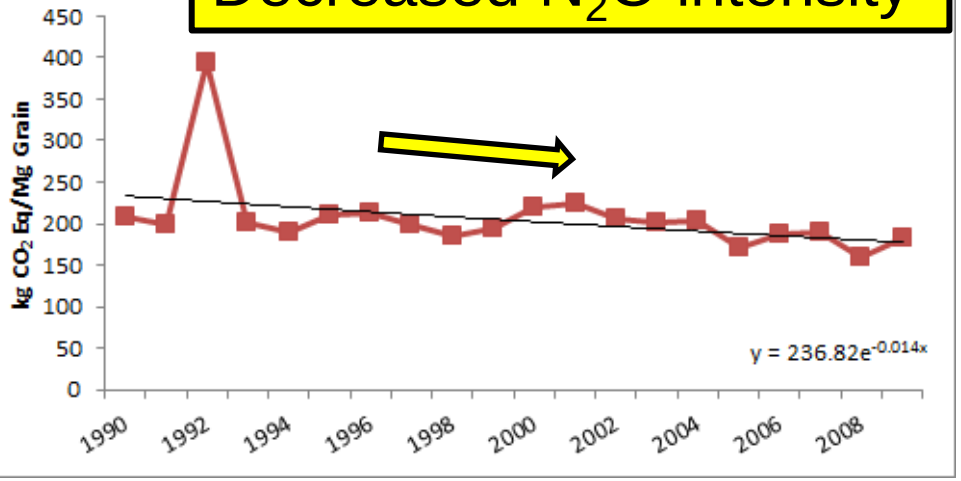
Trends in Ontario's agricultural efficiency

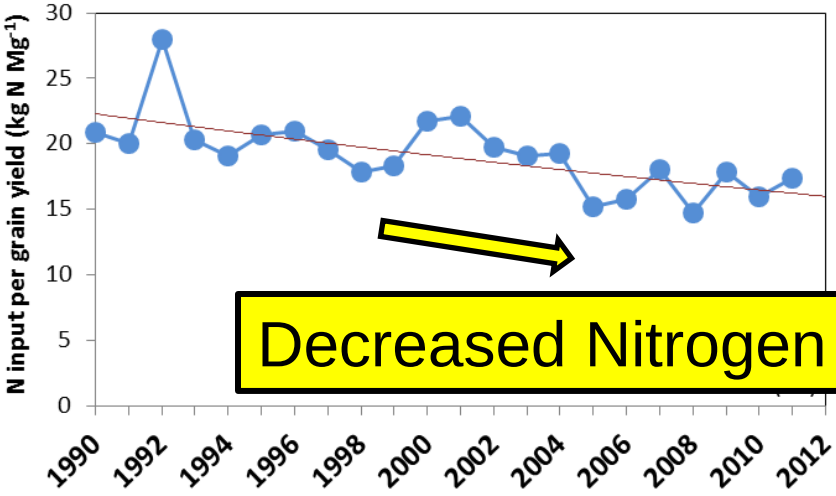
Data for corn grain



Increased Yields

Decreased N_2O intensity

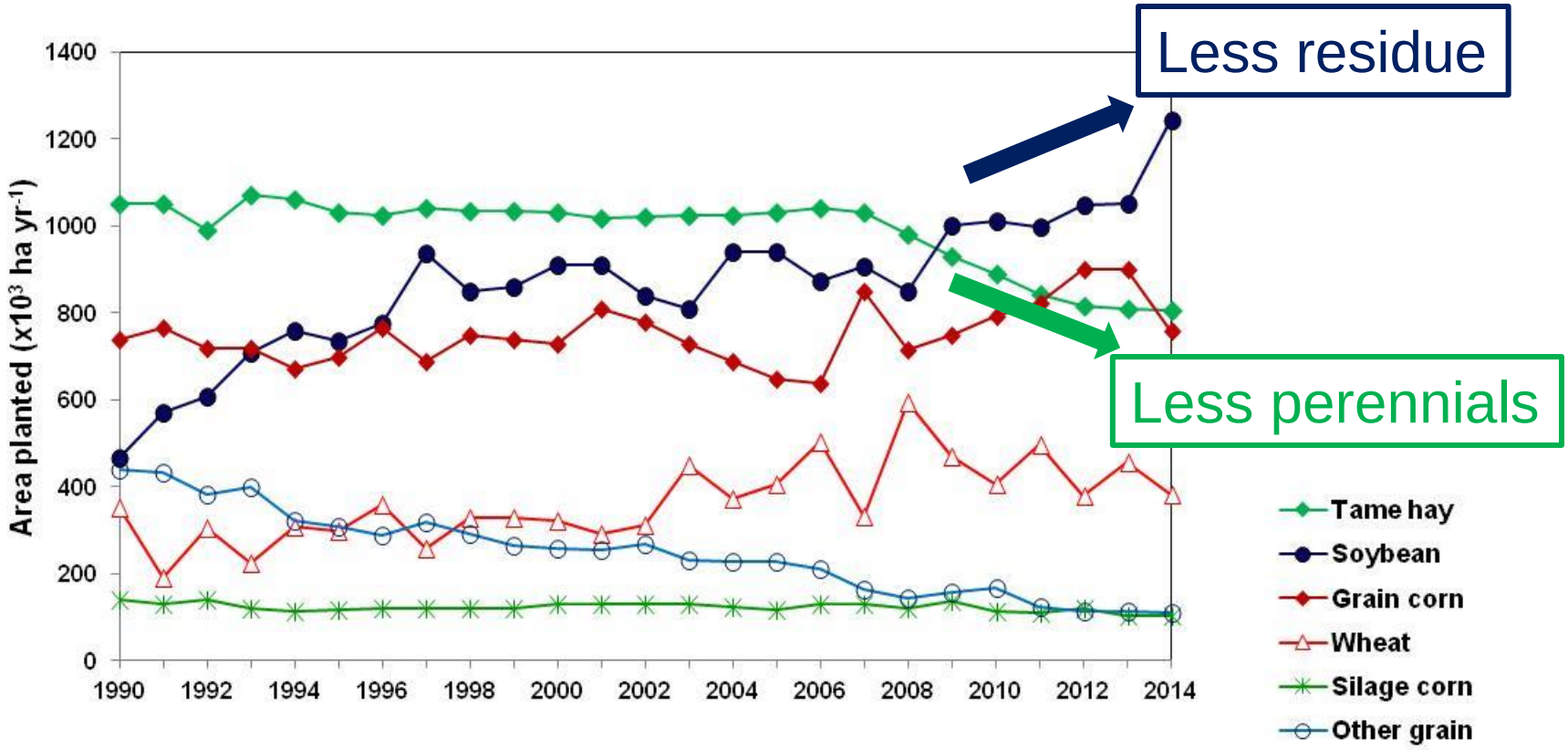




Decreased Nitrogen Use per Grain Yield

Jayasundara et al. (2014). CJSS

Recent trends in Ontario's cropped area



Mitigation practices for ↑C storage and ↓GHG emissions

Reduced tillage

tdaynard.com

Perennials

Restored wetlands

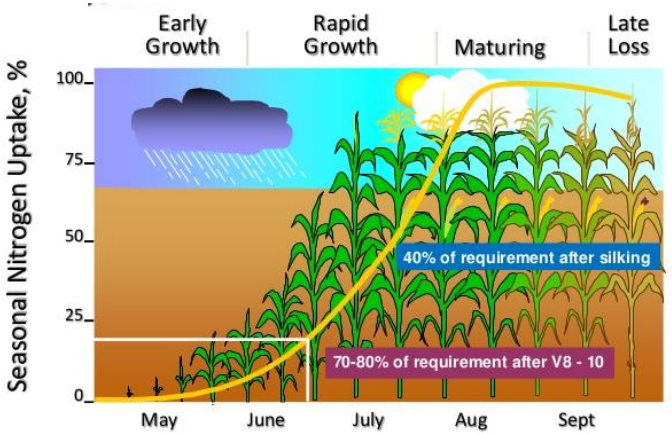
http://www.ducks.ca/

Cover crops

http://www.country-guide.ca/

Manure management

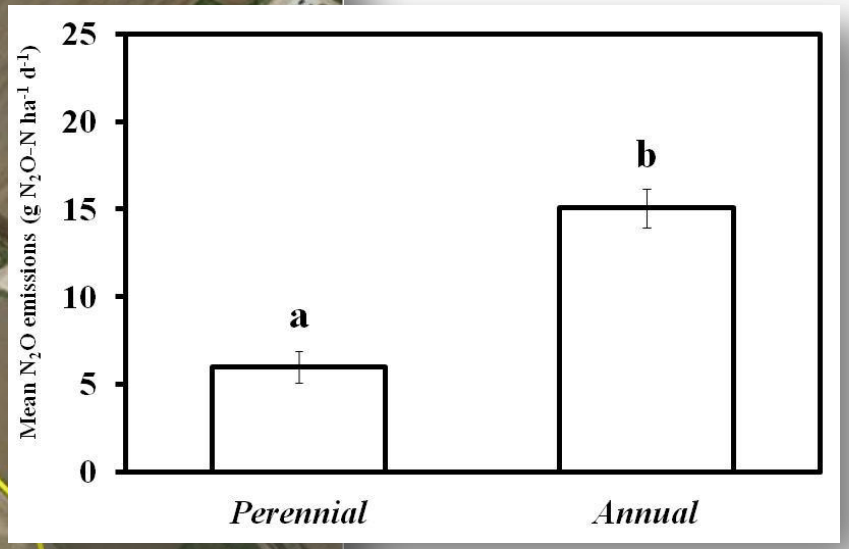
Improved nitrogen use



http://www.slideshare.net/NetNexusBrasil/schepers-precision-agriculture-2014

Field experiment on GHG emissions in annual and perennial crops used in dairy production systems (fall 2011- 2014)

Lower N_2O emissions for hay fields (~60%)



Abalos et al. (2015) Global Change Biology

Incorporating more feed from perennial sources could contribute to the reduction in C footprint of milk

Can we develop perennialized annual cropping systems to ↑C storage and ↓GHG emissions?

Concluding Remarks

- GHG sources and carbon sinks on the farm are varied and complex (off- and on-farm: need LCA approach)
- Promising mitigation strategies have been evaluated at the field scale providing evidence for reduction of GHG emissions (e.g. use of perennials, biogas capture)
- GHG emissions are intrinsically linked to agricultural production: need to use emission intensity (i.e. per yield) as metric
- Trade-offs/synergies between C uptake vs. GHG emissions and climate resilience vs. GHG mitigation need to be evaluated (e.g. cover crops)

Acknowledgements

- Funding (NSERC, CFI, IPNI, OMAFRA, DFC, GFO, AGGP/AAFC) and many collaborators
- Research team: post-docs (Shannon Brown, Diego Abalos, Katelyn Congreves, Kumudinie Kariyapperuma); research associate (Susantha Jayasundara); graduate and undergraduate students

Thank You!

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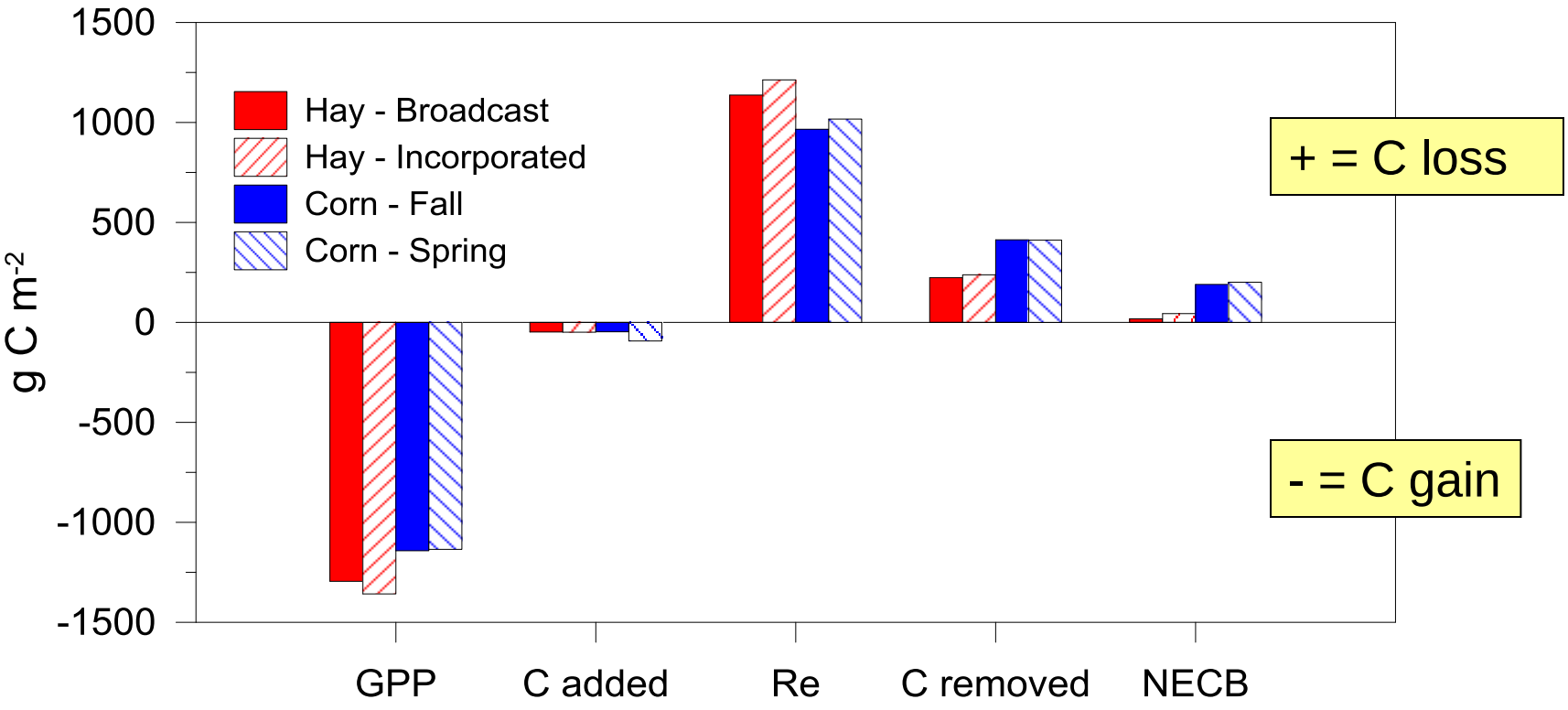
Research Projects

- Carbon budget of switchgrass vs. corn
- Mitigation practices for cropping systems:
  - Annual and perennial
  - No-till vs. conventional tillage in residual removal systems
  - Timing manure application (spring vs. fall)
  - Rapid incorporation or injection vs. surface-applied manure
  - Anaerobically digested vs. undigested manure
  - Inorganic N management (timing, source)
- CH_4 mitigation practices for manure management:
  - Anaerobic digestion and biogas capture
  - Reduced methanogen inoculum through complete or partial storage emptying

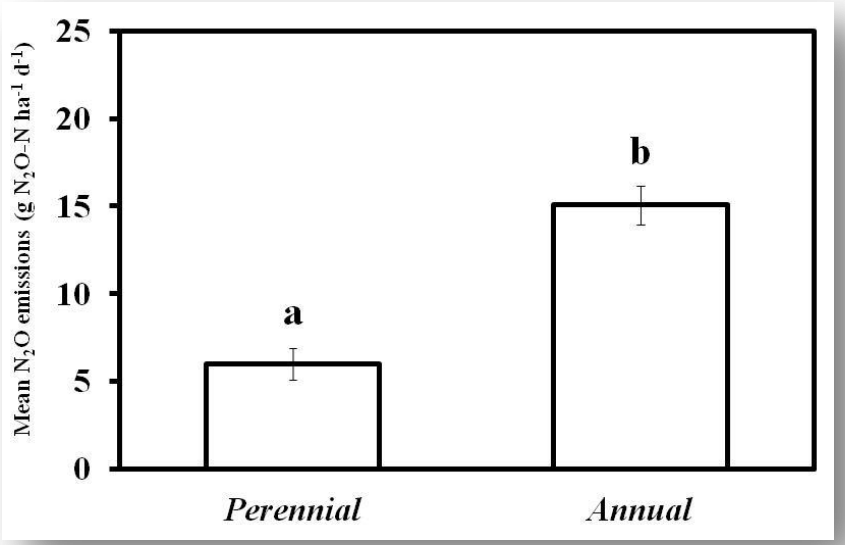
Over 3 years corn was **source** of C and hay field was C **neutral**



Data from M. Sulaiman

N_2O fluxes from annual and perennial crops used in dairy production systems

Lower emissions for hay fields (~60%)



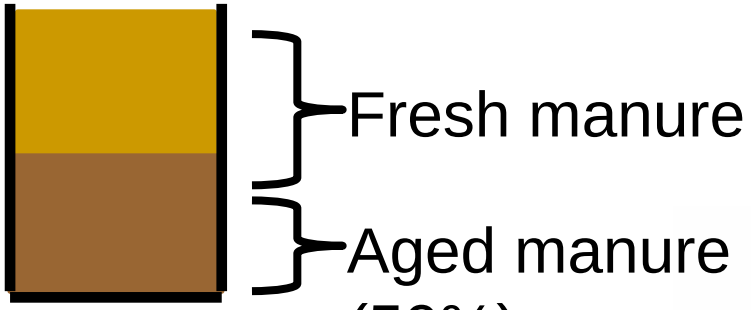
Abalos et al. (2015) Global Change Biology

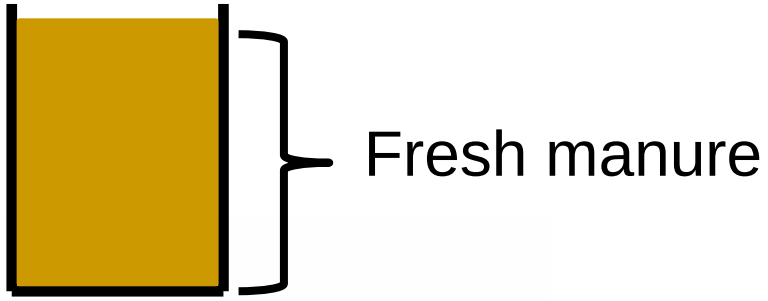
Incorporating more feed from perennial sources could contribute to the reduction in C footprint of milk

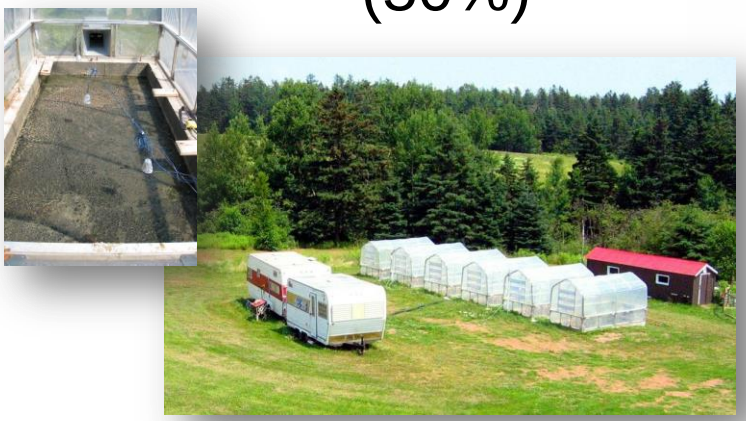
Manure Storage: Complete emptying

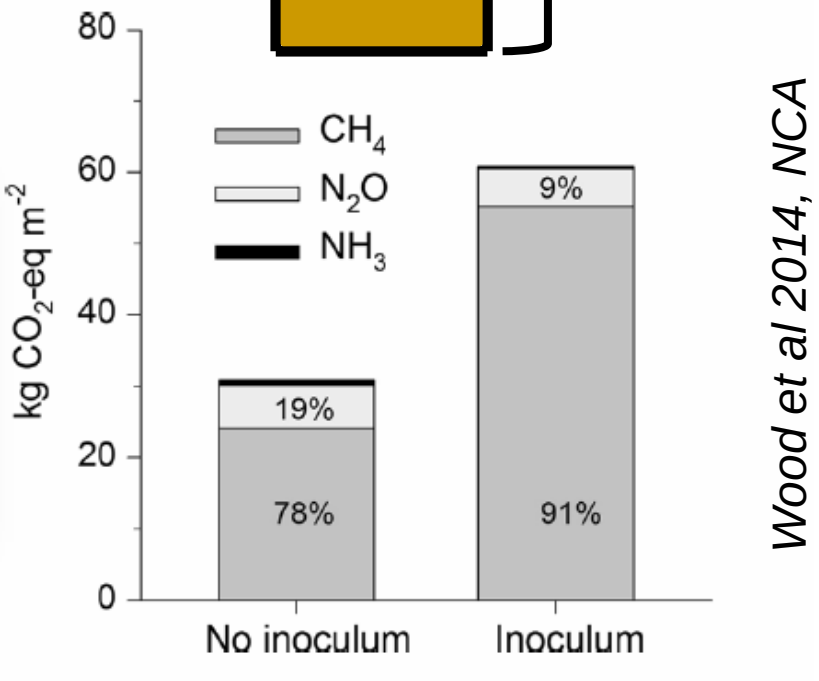
- Reduced methanogen inoculum through **complete emptying** resulted in 55% reduction in GHG emissions

Inoculated tanks VS. **Emptied tanks**









Wood et al 2014, NCA

Collaboration with R. Gordon and A. VanderZaag

Avoided emissions associated with biogas production