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Carbon sequestration in Prairie soils and their potential for climate change mitigation

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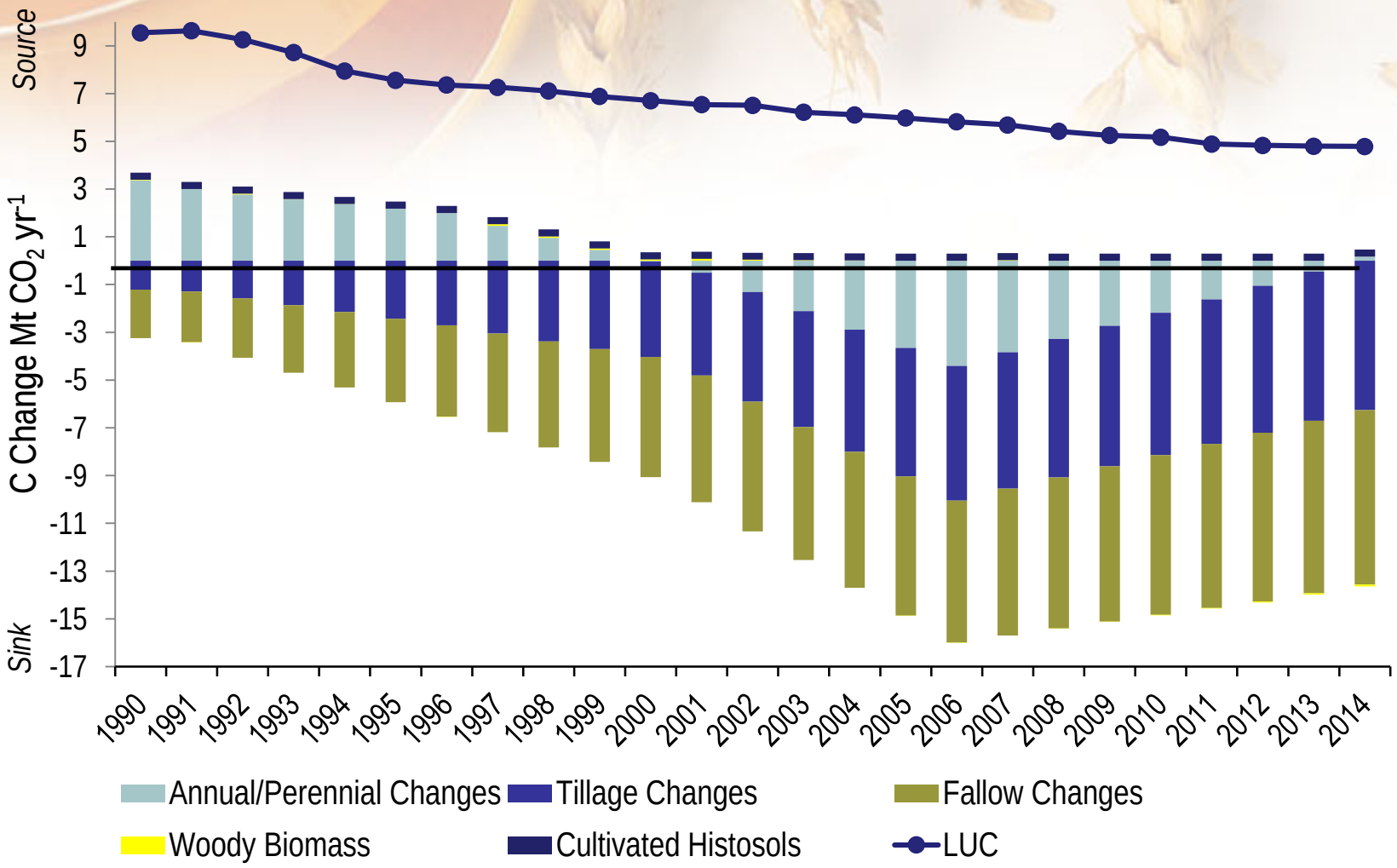
Canada

Outline

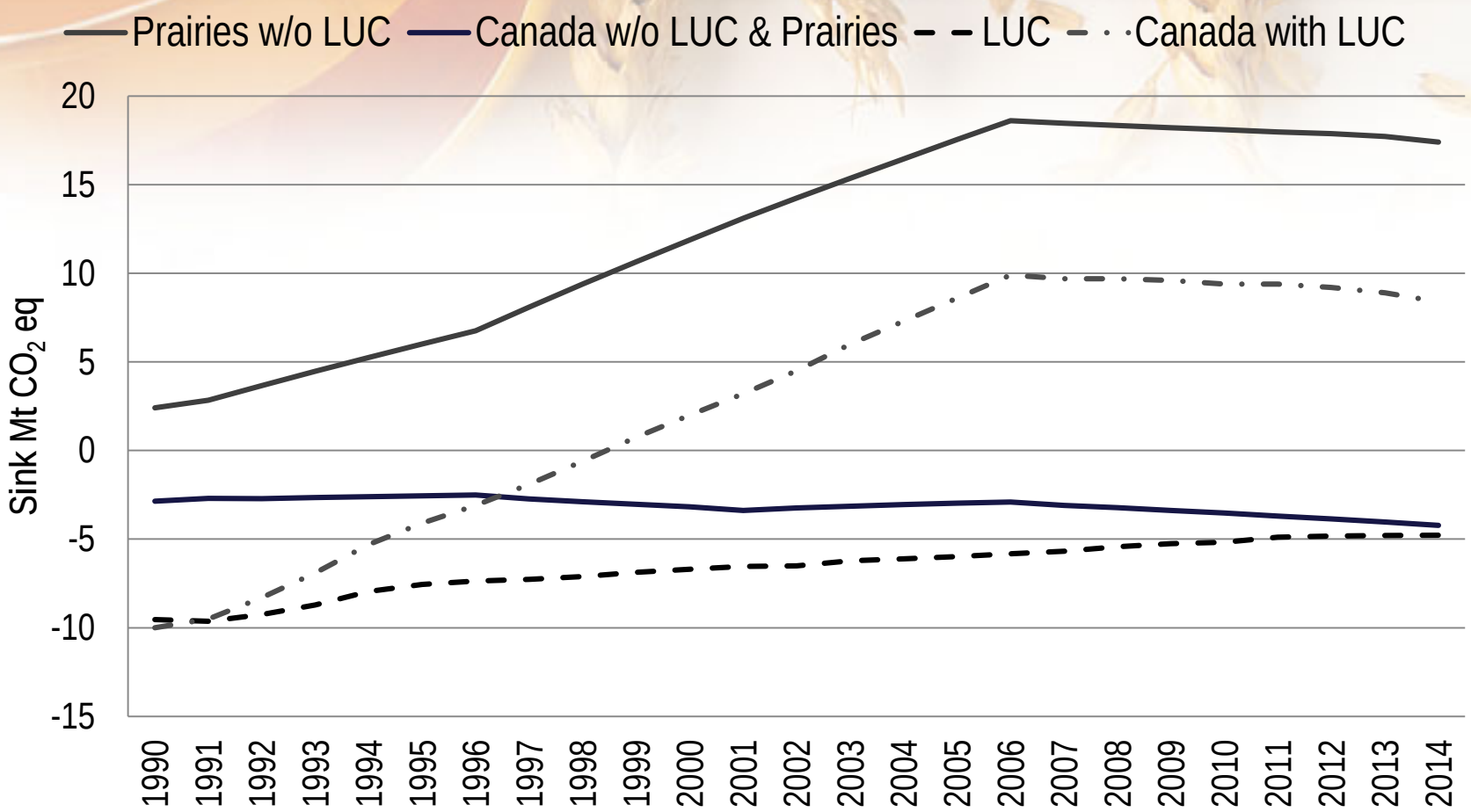
- Current Situation and Resulting Opportunities
- Further Opportunities

Canada reports limited types of soil C change



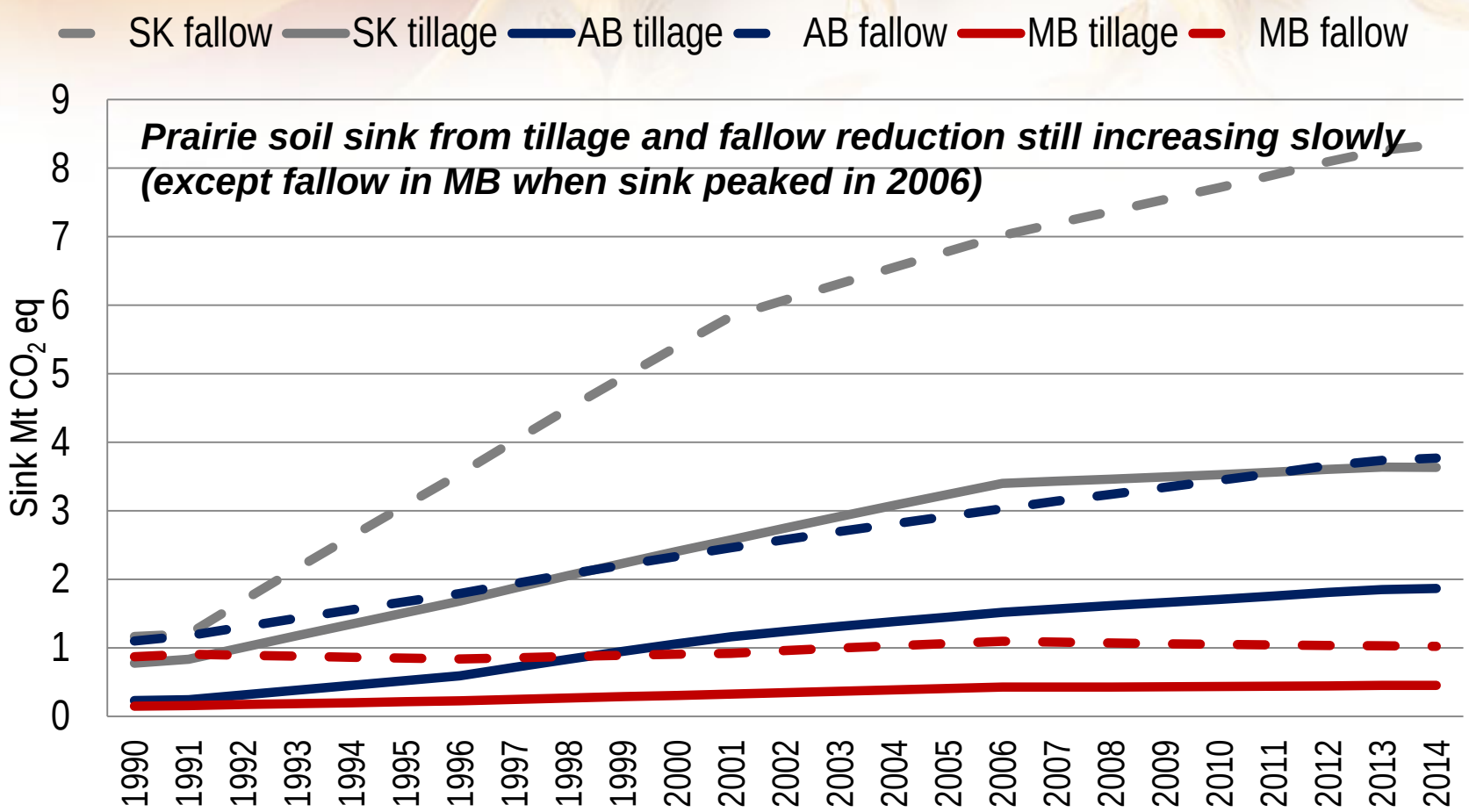
Source: National Inventory Reports, Environment and Climate Change Canada

Prairies Dominate Canadian Soil Sink



Land-Use Change (LUC) source is predominately forest clearing for new cropland

Reduced Fallow Dominates



Trees in Agricultural Landscape

- Intact shelterbelts in Saskatchewan sequestered 0.73 Mt CO_2 eq per year from 1990 to 2009. (Amichev et al. 2017)
  - Working on estimates of C loss in shelterbelt removal

Opportunity:
Land-Use Change – Small Area, Big Impact

- Breaking of forest to cropland

Year	Area (ha)	Reported Emission Mt (CO_2 eq)
2014	12 049	4.8

- Reducing land use change is lowest hanging fruit for increasing net C sequestration
- Achilles heel for Canadian reputation
  - Canadian canola sales into Europe for bioenergy has to be certified not to come from recently deforested land
- Provincial jurisdiction
    - BC is example of province with no net deforestation policy

Opportunities

- Still some opportunities to further reduce tillage and summerfallow
  - Increase reduced tillage systems rather than adding new pure low-disturbance direct seeding
- New tree plantings?
  - Silvopastural systems
  - Planting unproductive land

- Reward maintenance of existing C stocks (ecosystem services)

Further Opportunities

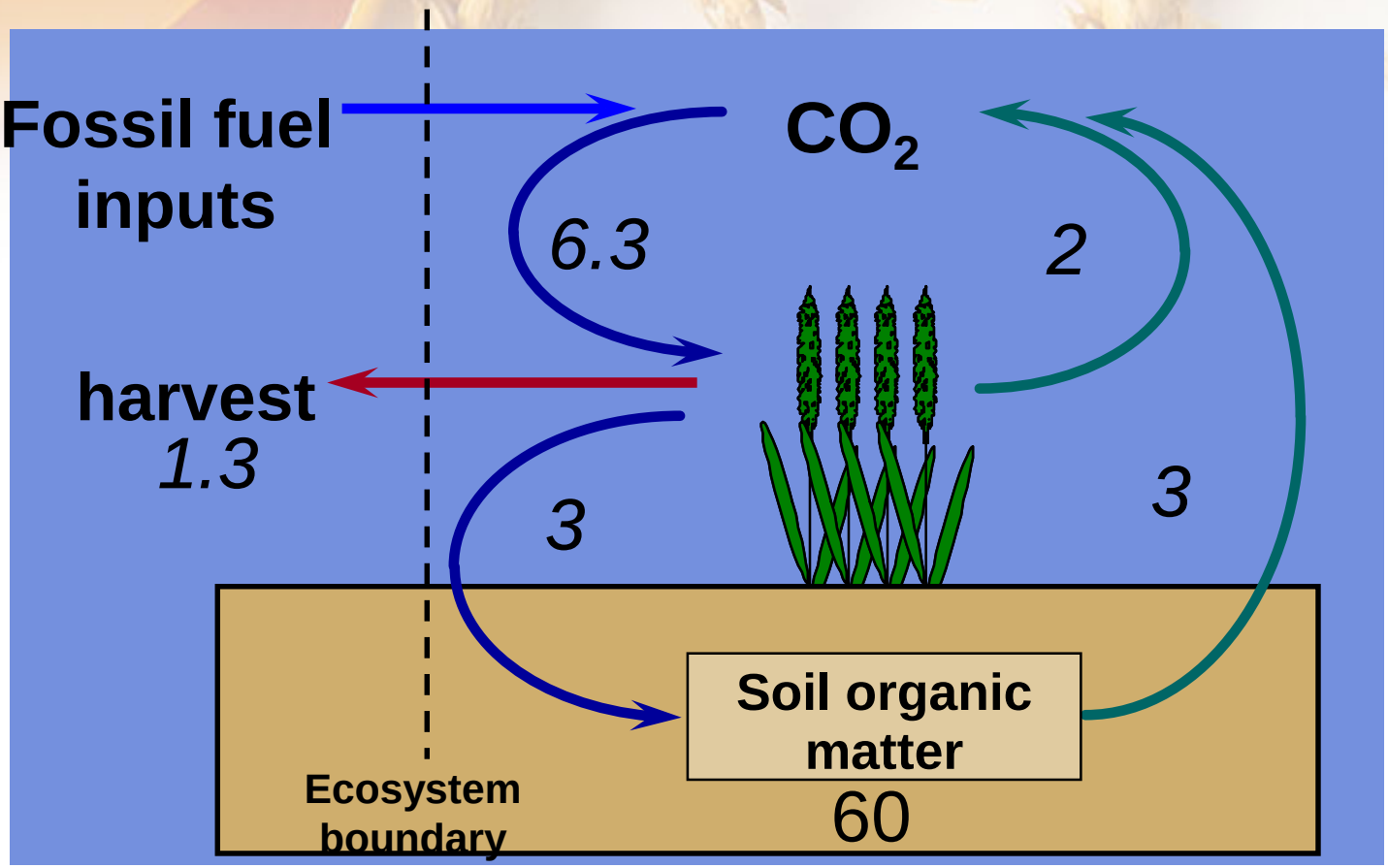
- Increase C input to soil
  - Biochar
  - Crop yield
  - Crop type
  - Continual plant growth
- Pasture management?

Biochar

Image: UC Davis Biochar Database

- Product of heating biomass with limited oxygen
  - Infinite variety depending on biomass source and production conditions
  - Usually co-product of energy/fuel production
- Can improve soil properties and nutrient availability
  - Prairie soils, story not clear yet
- Long-lived carbon sequestration, potential limit is the limit of biomass supply
- Need careful life-cycle assessment to capture net benefits from using crop residues or purpose grown crops as biomass source
  - When energy from production used to displace fossil fuels, it can provide excellent greenhouse gas mitigation

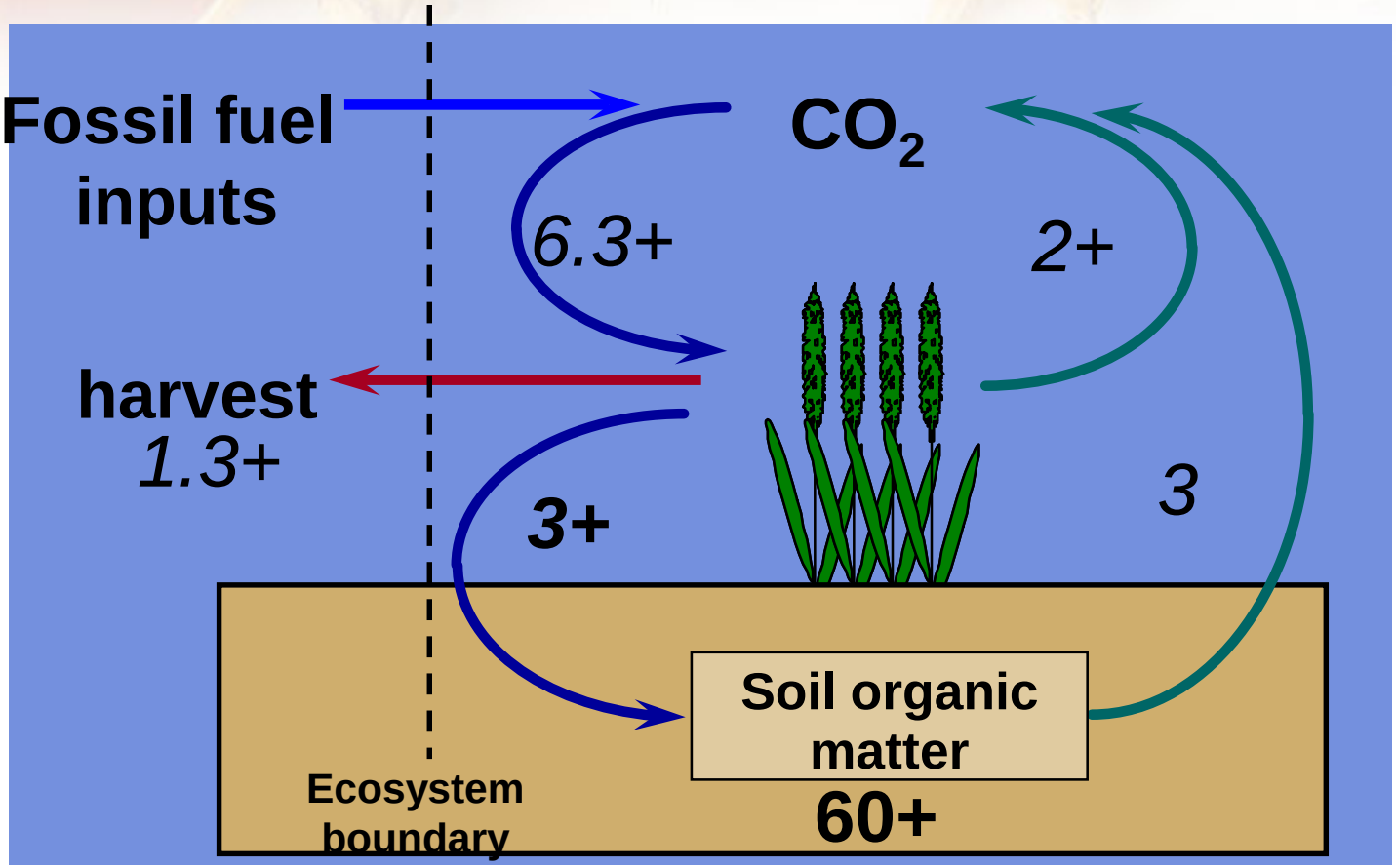
Soil C stock result of balance between C input and losses



C *Fluxes* and Stocks **(t/ha)**

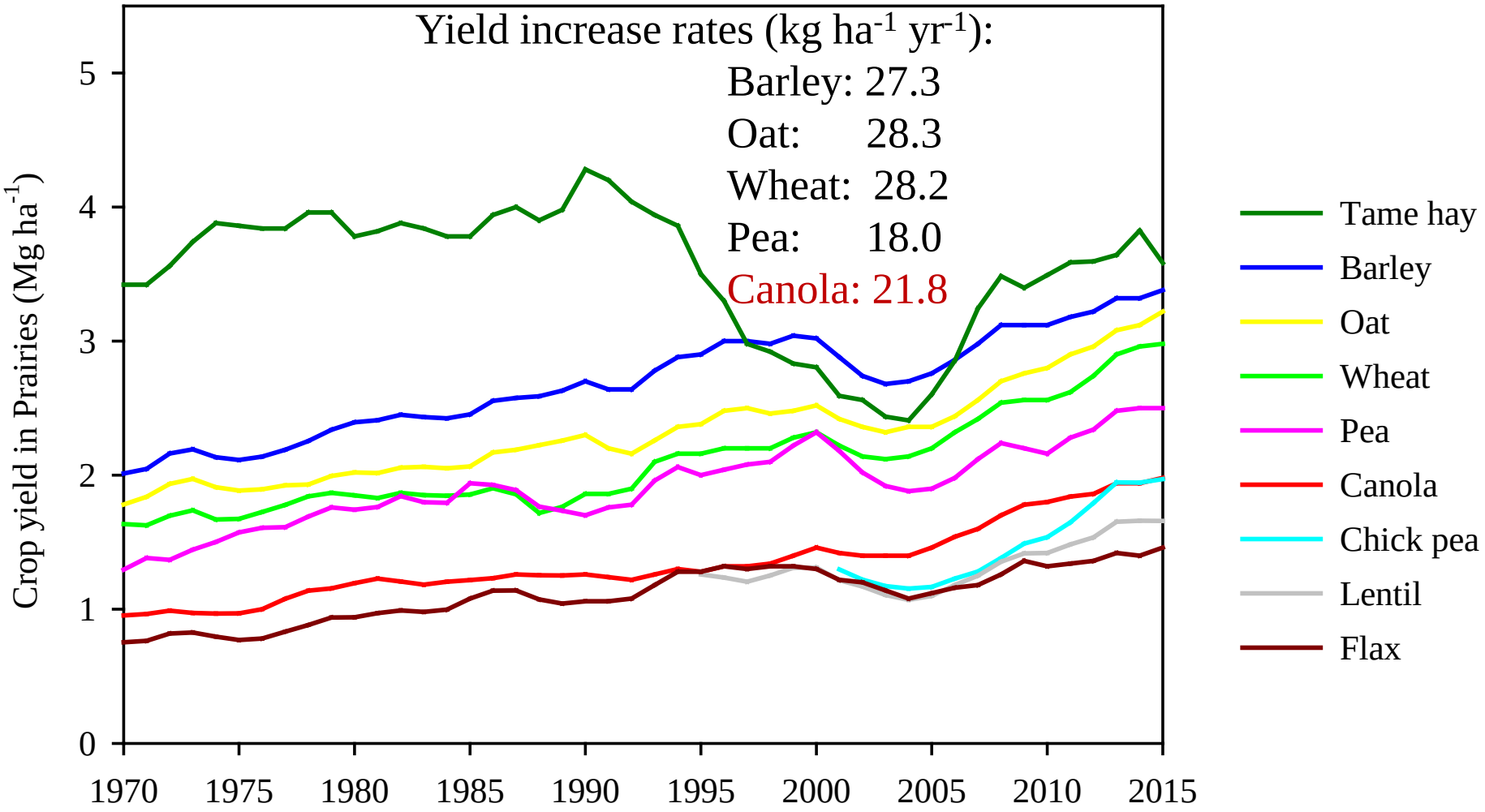
Increased yields increase C sequestration but *Canada does not yet report this effect*

- Increased C input produces an imbalance that increases soil C stocks



C *Fluxes* and Stocks **(t/ha)**

Crop yields have been increasing (except hay)



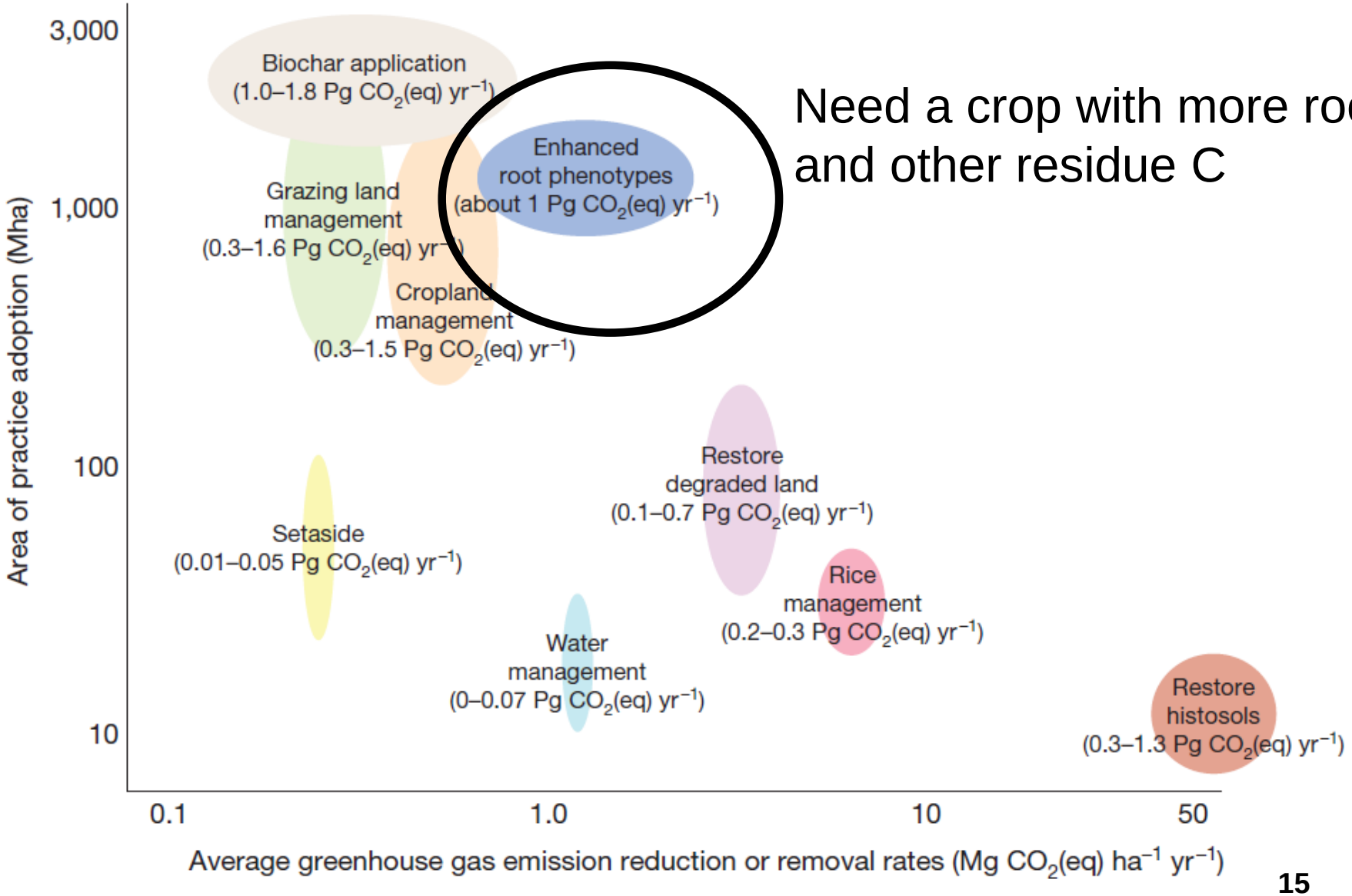
(Data source: Statistic Canada)

(5-year moving average)

Continual plant cover increases C input

- Cover crops, relay cropping, green manure crops
- Short period of warmth limits opportunity in prairies

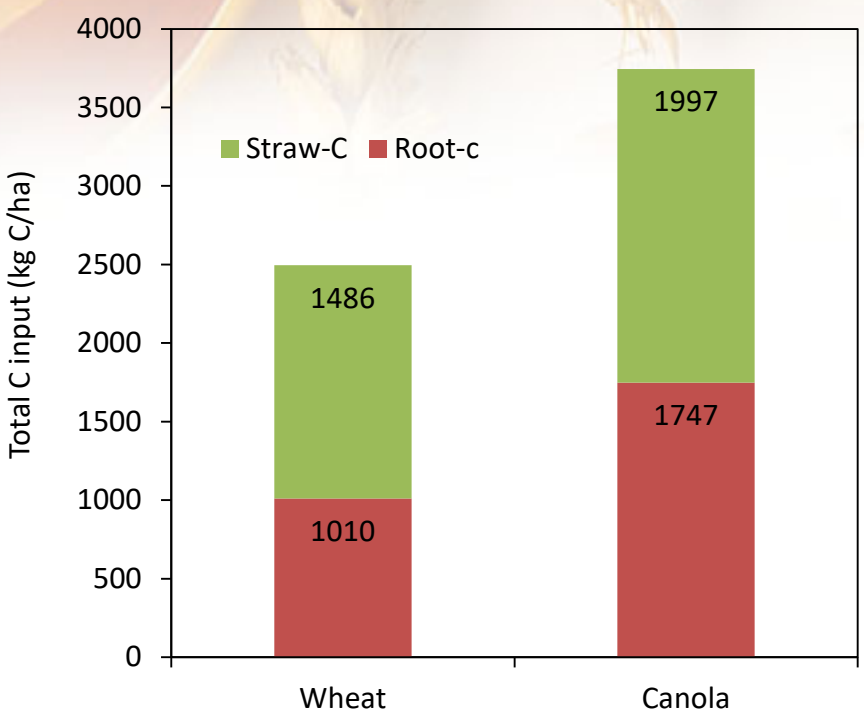
Paustian et al. 2017, Climate-Smart Soils, *Nature*



Need a crop with more roots and other residue C

Effect of SOC change from changes in C input (productivity and crop type) not estimated

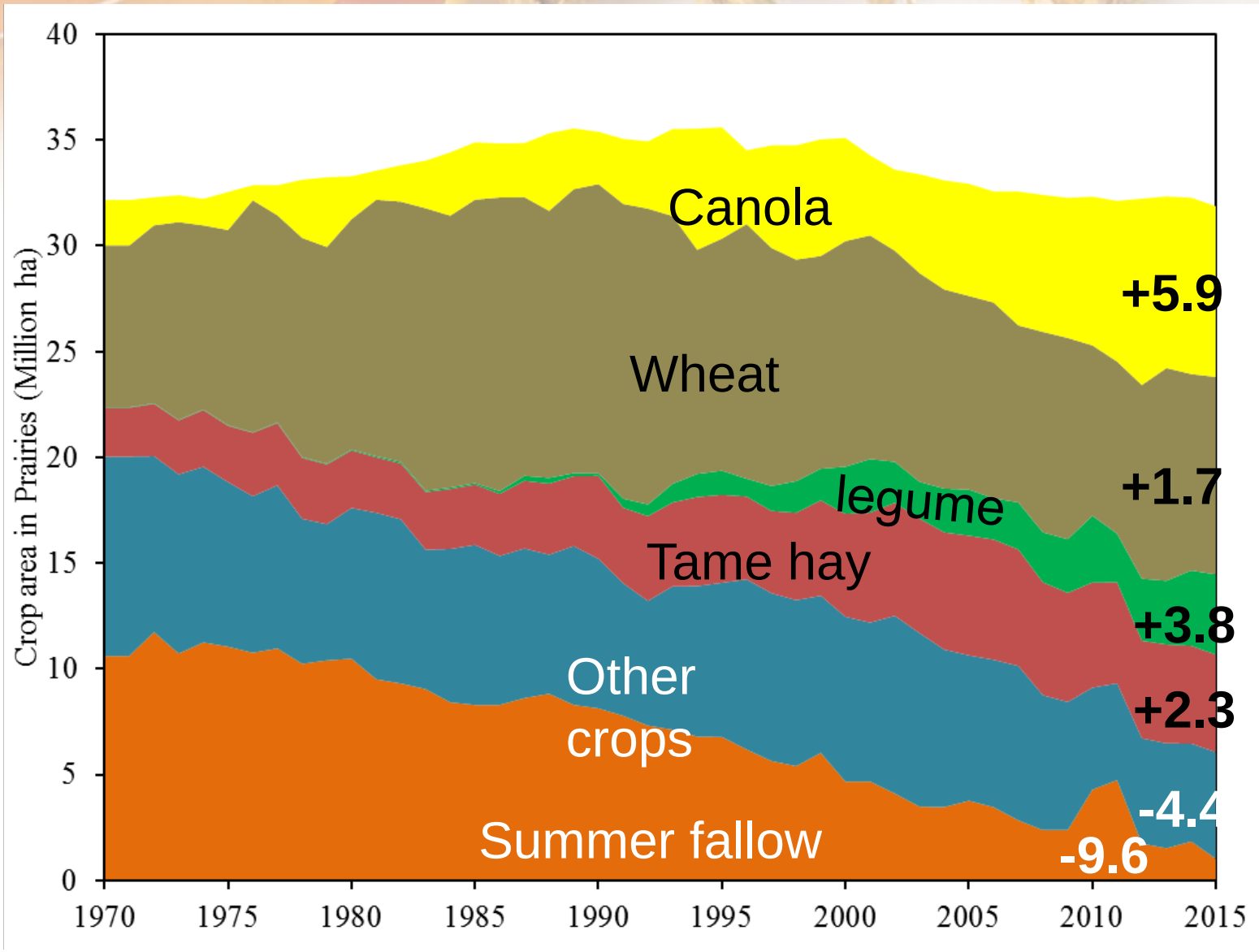
90% ground cover after wheat harvest



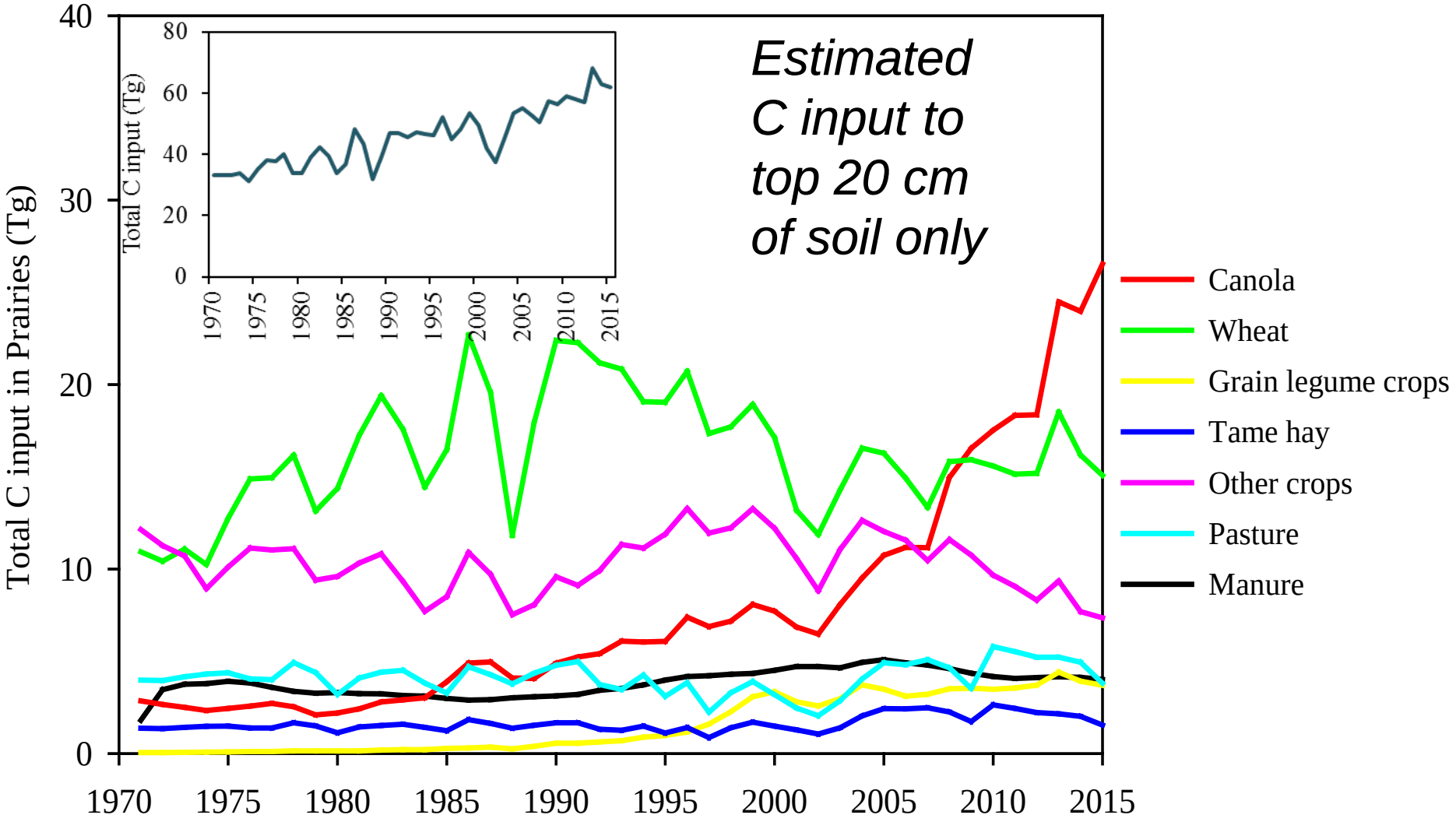
75% ground cover after canola harvest

- Average SK 2014 yield: 2724 kg/ha for wheat and 1810 kg/ha for canola
- Total C input by canola was 1.5 times of wheat.

Area of Crop Types Changing

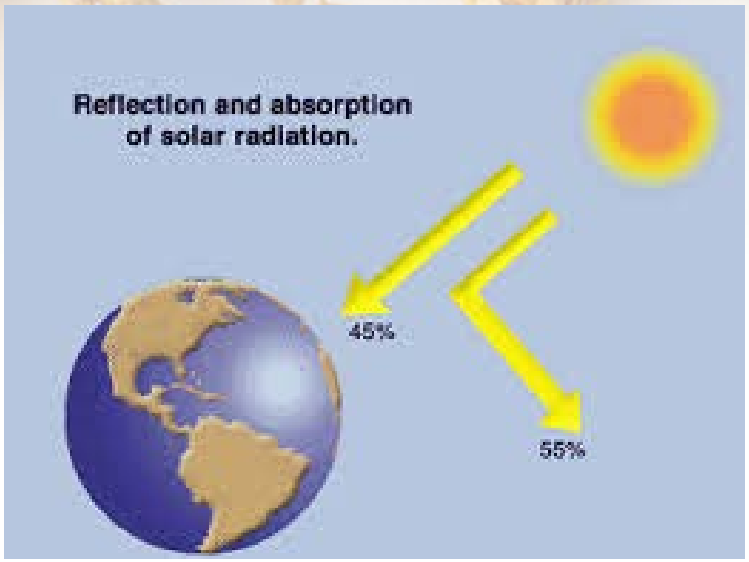


Prairie C input increasing by about 1% per year with *½ of increase due to canola alone*



Other means of mitigating radiative forcing

- Land surfaces that are more reflective have important cooling effect
  - Example: reflectance change from planting coniferous tree in snowy climate causes more warming (radiative forcing) than is countered from removal of CO_2 by the growing tree



- Canola is the most reflective prairie crop!
  - Reduces radiative forcing by 1.6 mW m^{-2} compared to wheat
  - Residue cover, summerfallow reduction, and increased snow catch also have cooling effect
- Breeding opportunities:
  - For increased crop reflectance (also adaptation to warmer temperatures)
  - Increased C input to soils, especially roots

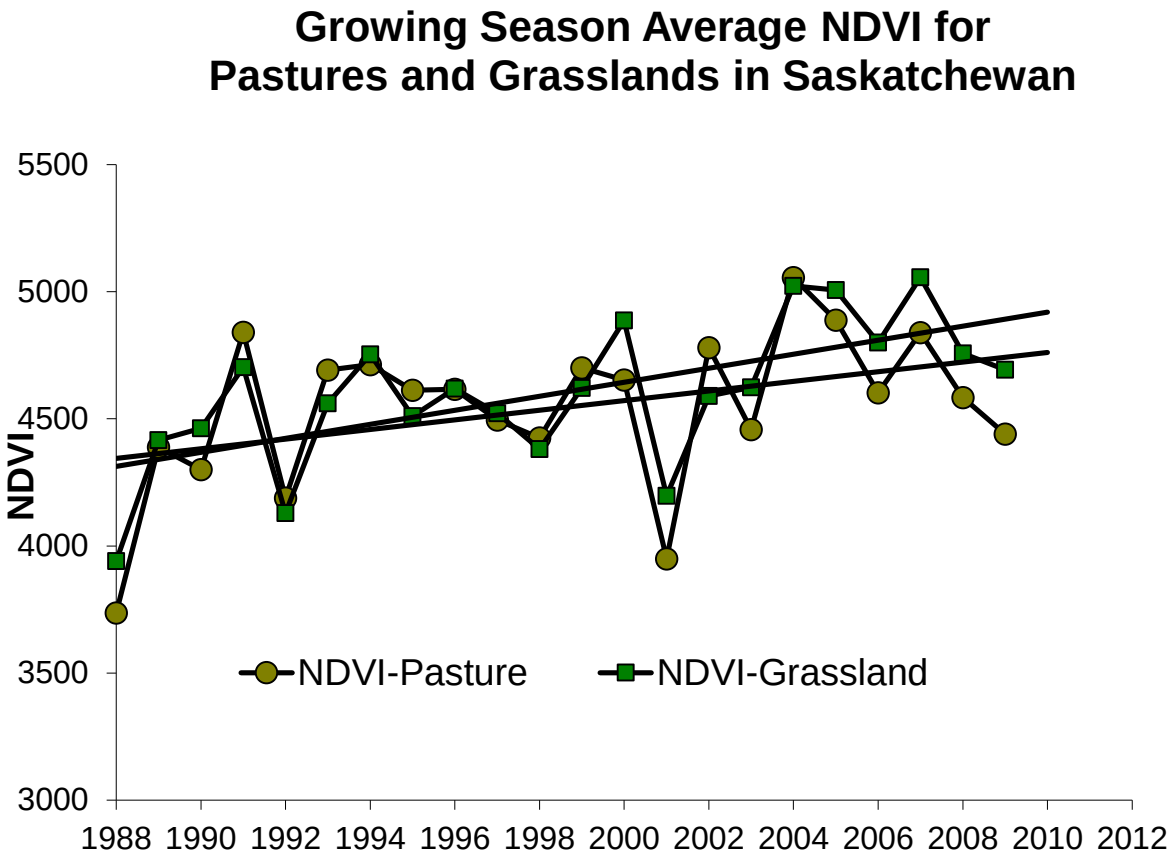
SOC change on grassland

- Grazing management on grasslands is complex and changes depending on annual situation – not easily categorized.
  - Practice-based estimates not workable.
- SOC not clearly related to vegetation condition due to species shift.
- SOC increasing by 19* to 72** kg C/ha/yr by grazing compared with non grazed controls.
- Little known about modern grazing practice with intense grazing then good recovery periods.

*Wang et al. 2014. Rangeland Ecol. and Manage.
**Wang et al. 2016. Sci.Reports,

Use of Vegetation Condition to Estimate C change of grassland?

- *E.g. Normalized Difference Vegetation Index (NDVI) shows increasing grassland "greenness" over time consistent with generally increasing SOC*



Li et al. 2013. J. Remote Env.

Legume Crops

- Neither an important C sequestration benefit or detriment but generally beneficial to whole diversified cropping system productivity
- Main benefit is reduced emission from chemical N fertilizer production and less N_2O emissions
  - 10-50% reduction in total GHG emissions in cropping systems when replacing cereal or oilseed crops

Summary

- Prairie agriculture can be justly proud in in its accomplishments for C sequestration primarily due to reduced fallow and reduced tillage
  - Limited room for increasing that C sequestration
  - Preserving C stocks and their ecosystem services is important
- Quantifying the effect of increased C input on soil C is huge opportunity
  - Canola is the coolest crop
- Biochar is an new opportunity if the infrastructure is established
  - More research needed
- Quantifying the C sequestration for pastures is challenging
- Manage landscape holistically to optimize ecological goods and services (incl. C storage and harvest), lower N_2O emissions, and increase reflectance
  - Increased use of earth observation by drone & satellite to quantify

THANK YOU!

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