

Rangeland Ecosystem Goods and Services: ***A review of current research efforts in Alberta***

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What are EG & S?

“Benefits to all of society from the existence of grasslands”

**Water Purification &
Flood Mitigation**



Carbon/GHG Storage



Pollination



Forage Production



Biodiversity/Habitat

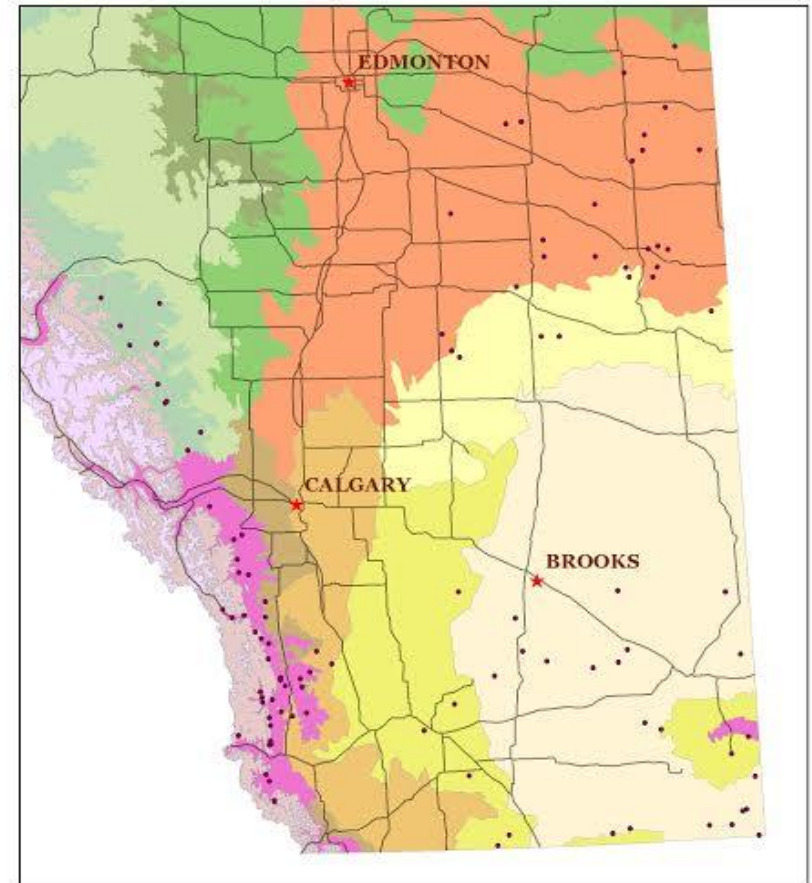


Rangelands and EG&S:

Recent findings of a University of Alberta/AEP Collaboration

- Sampled 114 grassland exclosures maintained by Alberta Environment & Parks
- Assessed plant biomass, composition & diversity, as well as carbon (C) storage

Carbon Benchmarking Sites in Alberta



Rangelands and EG&S

- Examined areas inside and outside long-term cattle exclosures

Harold Creek, Upper Foothills

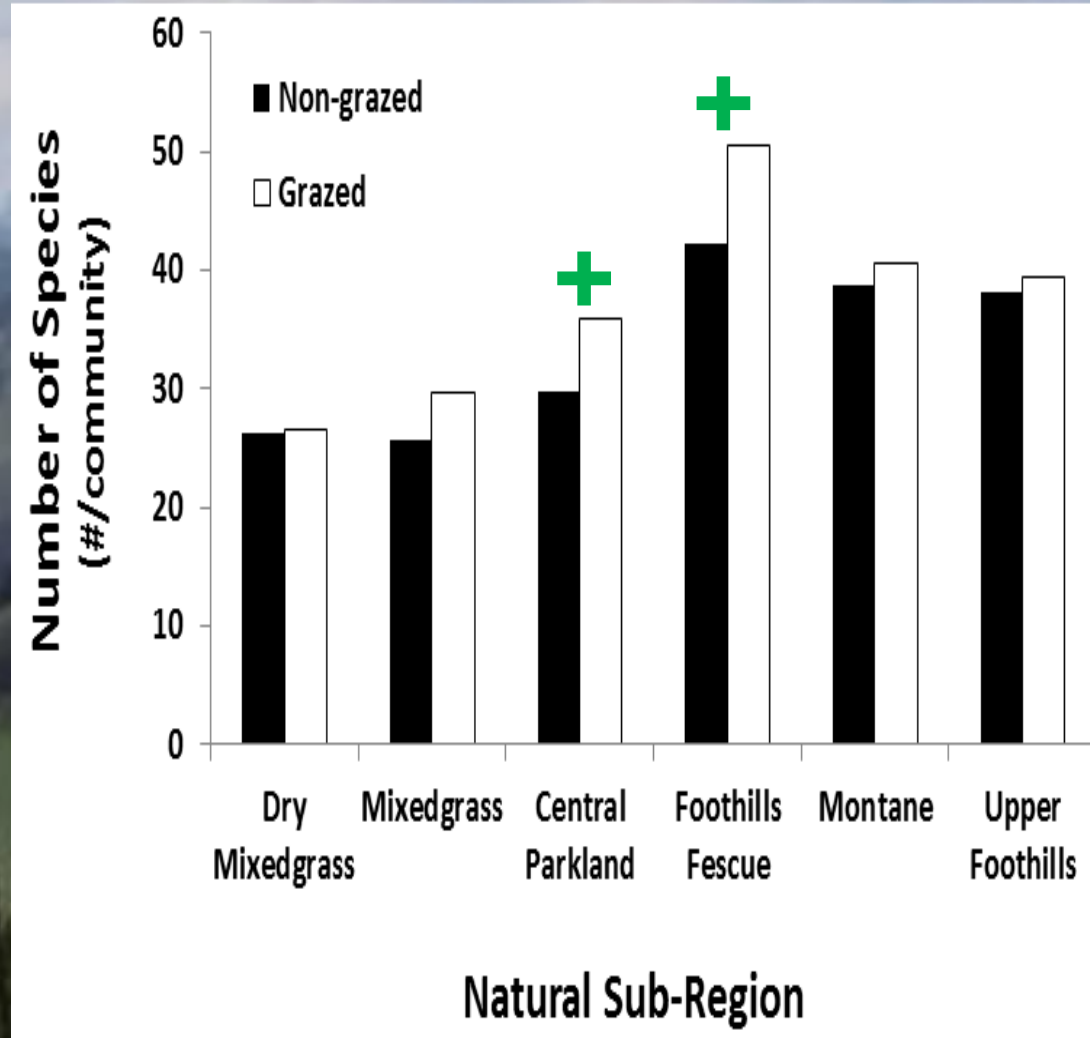


Schuler, Dry Mixedgrass

Grazing & Plant Biodiversity

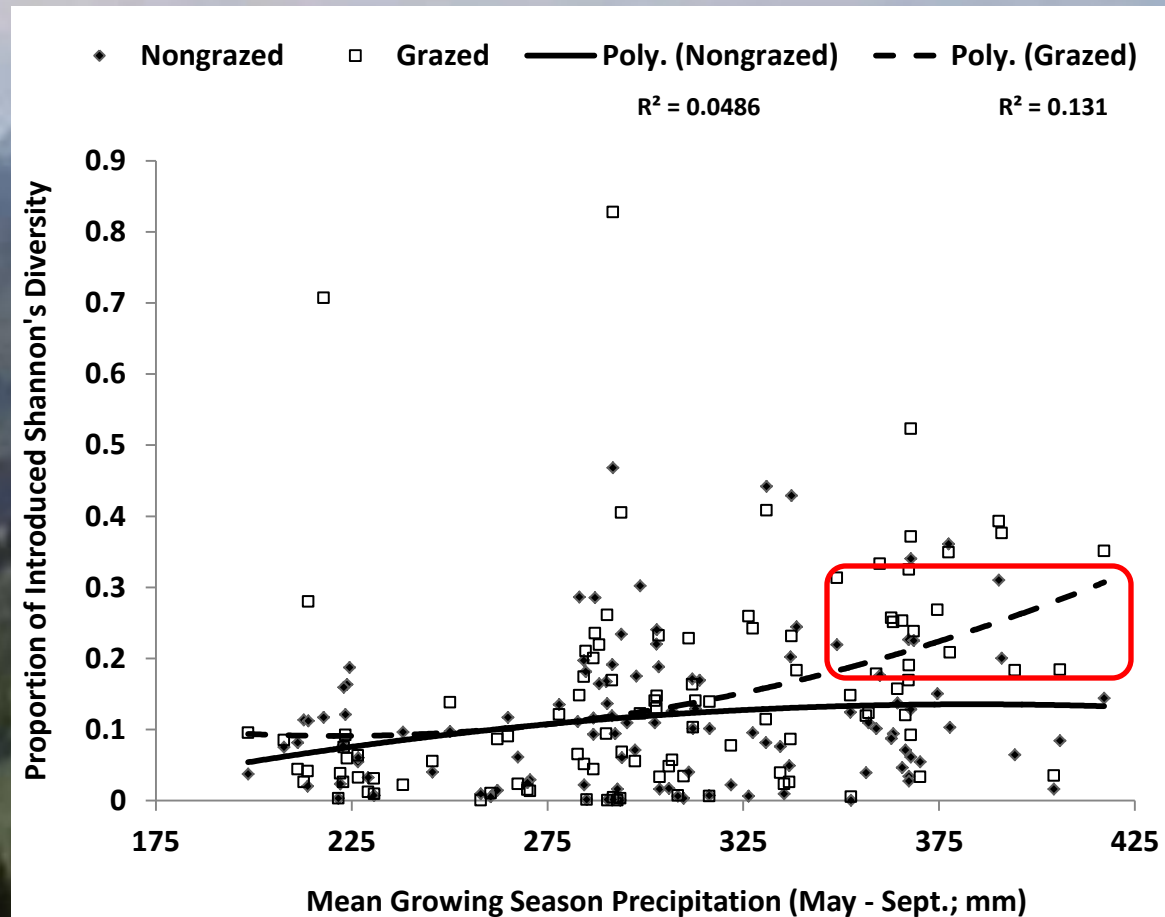


- Plant diversity peaked in mod-high rainfall areas
- Diversity increased with long-term exposure to grazing by releasing plant species suppressed in the absence of ungulates
- Largest increases in Parkland and Foothills Fescue



Does Grazing Alter the Abundance of Introduced Plant Species?

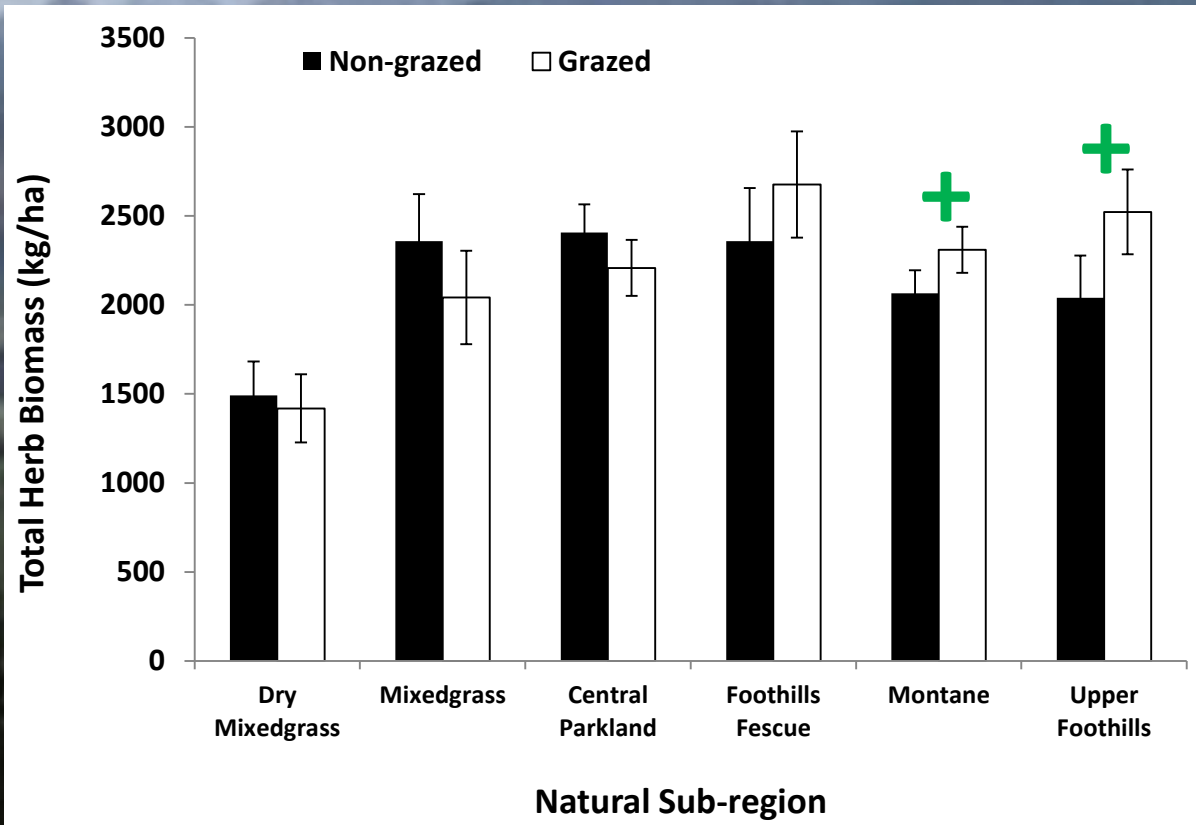
- Introduced species represented about ~10% of communities
- Grazing facilitated the increase of introduced spp. but only under moist conditions!
- Semi-arid grasslands with < 350 mm (14") may have greater resistance to invasion



Long-Term Grazing Impacts on Grassland Productivity

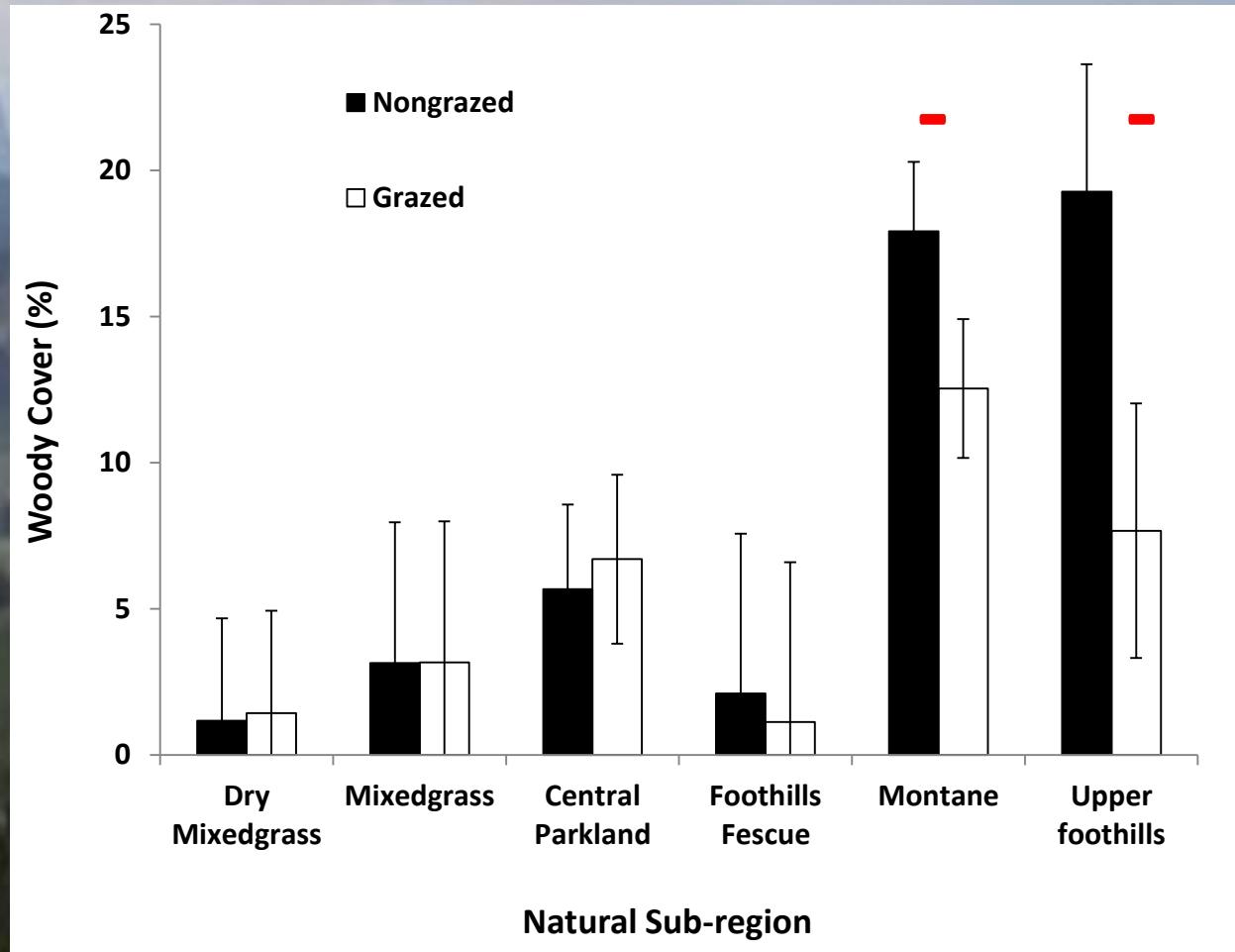
➤ Grazing enhanced production in high rainfall grasslands of SW Alberta

➤ Introduced species *may* play a role in enhancing herbage productivity



Exposure to Grazing May Limit Shrub Encroachment

- Grazing was tied to lower shrub cover in the Rocky Mountain Forest Reserve
- Largest reductions were in the Upper Foothills (grazing allotments)



Rangelands & Carbon Storage

(Mitigation of Rising CO₂ Levels – “Greenhouse Effect”)

Grasslands store 10 - 30% of the world's organic carbon (C)

Temperate grasslands (~8% of earth's surface) contain more than 300 Gt C:

- 9 Gt in plants (3%)**
- 295 Gt in soils (97%)**



Why Have Grasslands Accumulated Large Amounts of Carbon?

Perennial grasslands have high root to shoot ratios
(e.g. ~7:1 in Mixedgrass Prairie; R.T. Coupland, Matador, SK)



What Changes Soil Carbon?

Cultivation (land use conversion) leads to the rapid loss of 30-50% of soil C (Burke et al. 1995; Lal 2002)



'Furnace Plots' from S. Alberta



➤ Initiation of continuous wheat cropping led to the loss of 19% of grassland C:

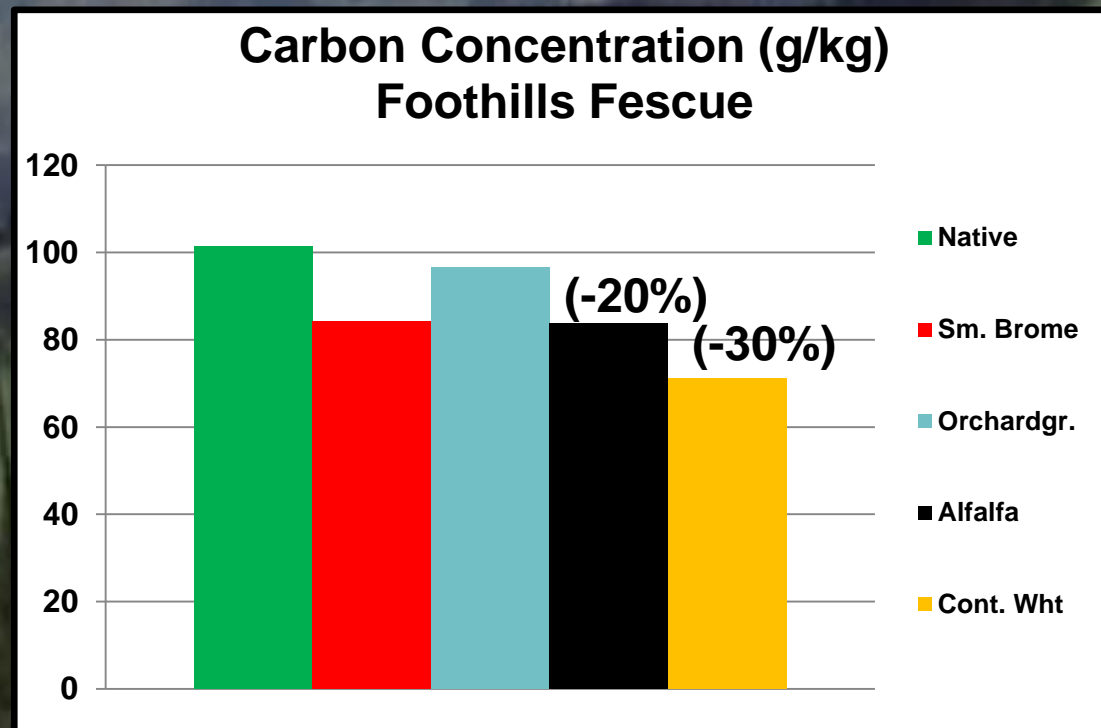
-1.7 tC ha⁻¹ yr⁻¹ for first 4 years

-0.32 tC ha⁻¹ yr⁻¹ for next 9 years

Carbon Loss Also Varies Regionally:

Modest Declines in Foothills Fescue

Soil C was 20-30% less 5-6 yr after conversion of a grassland with favorable moisture

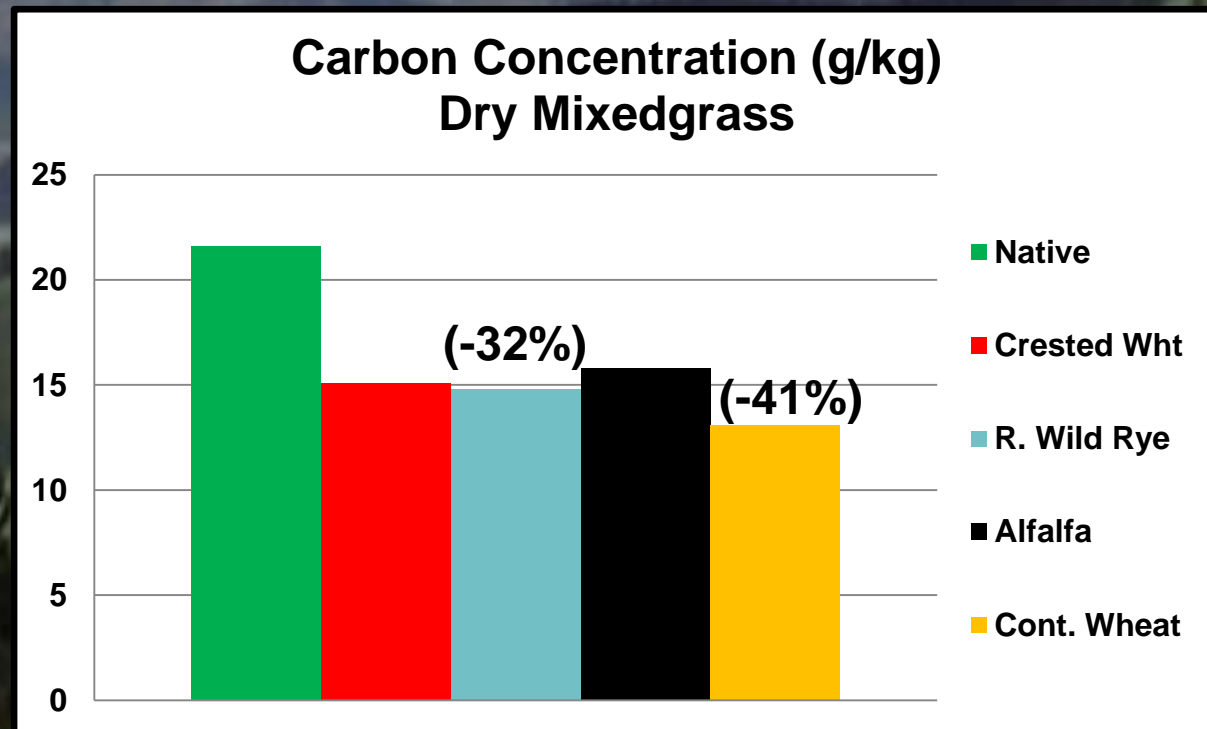


Source: Whalen et al. (2003)

Carbon Losses Under Various Land Uses:

Larger Declines in Mixedgrass Prairie

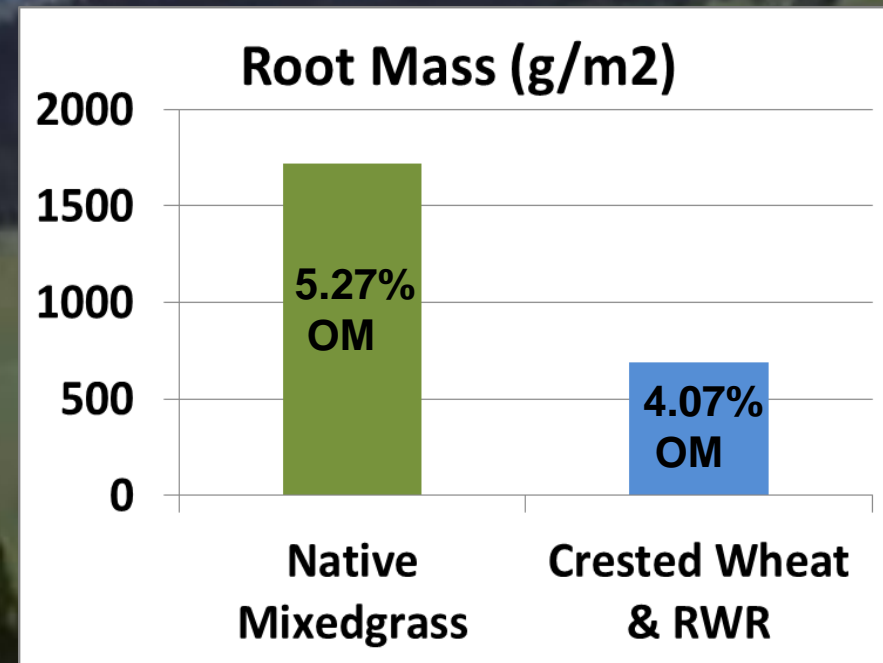
Soil C dropped 30-40% 5-6 years after the conversion of arid grassland



Source: Whalen et al. (2003)

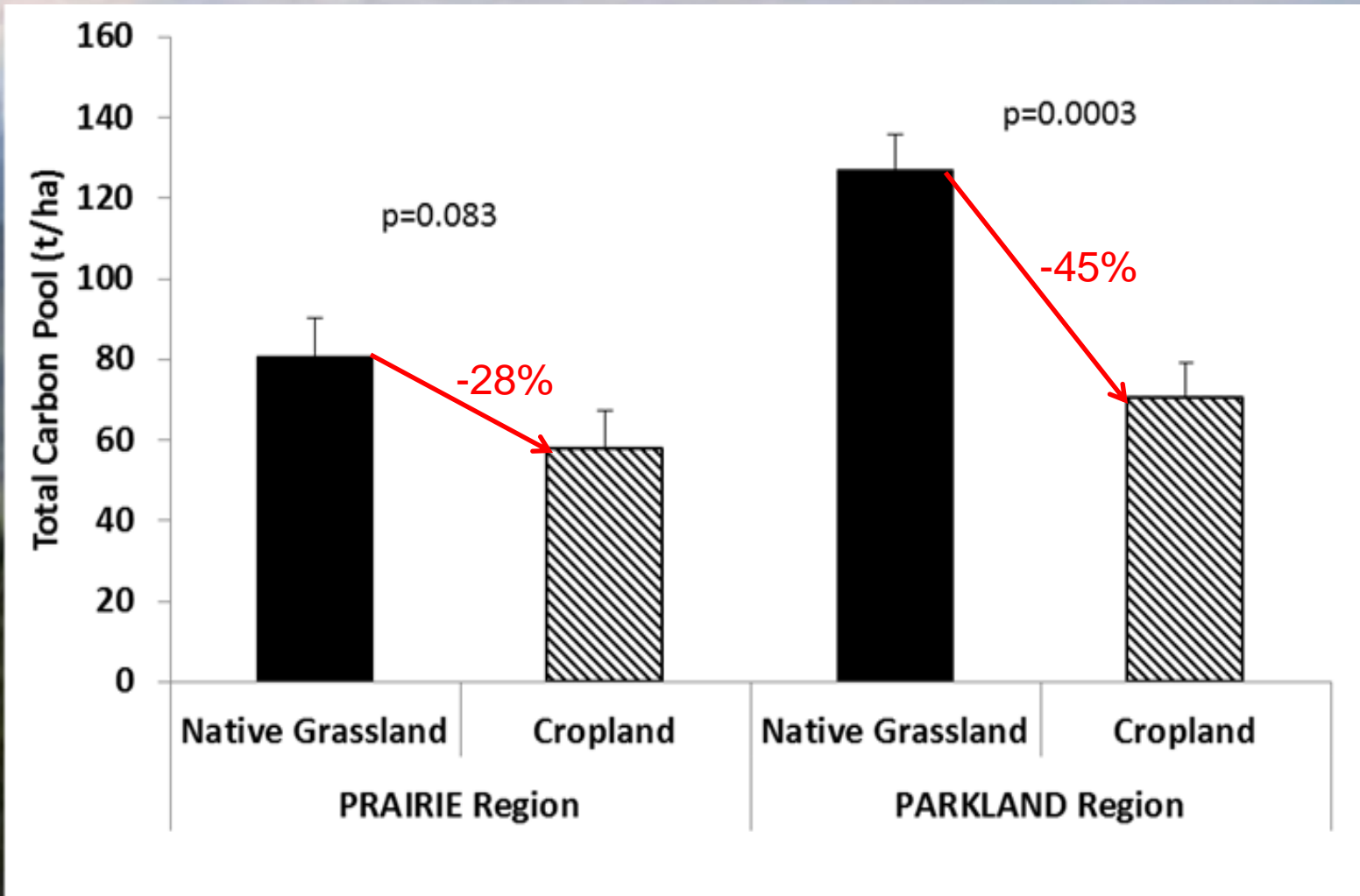
Why are Tame Forages Less Effective at Carbon Storage?

- Tame forages have lower root mass & OM than native grassland



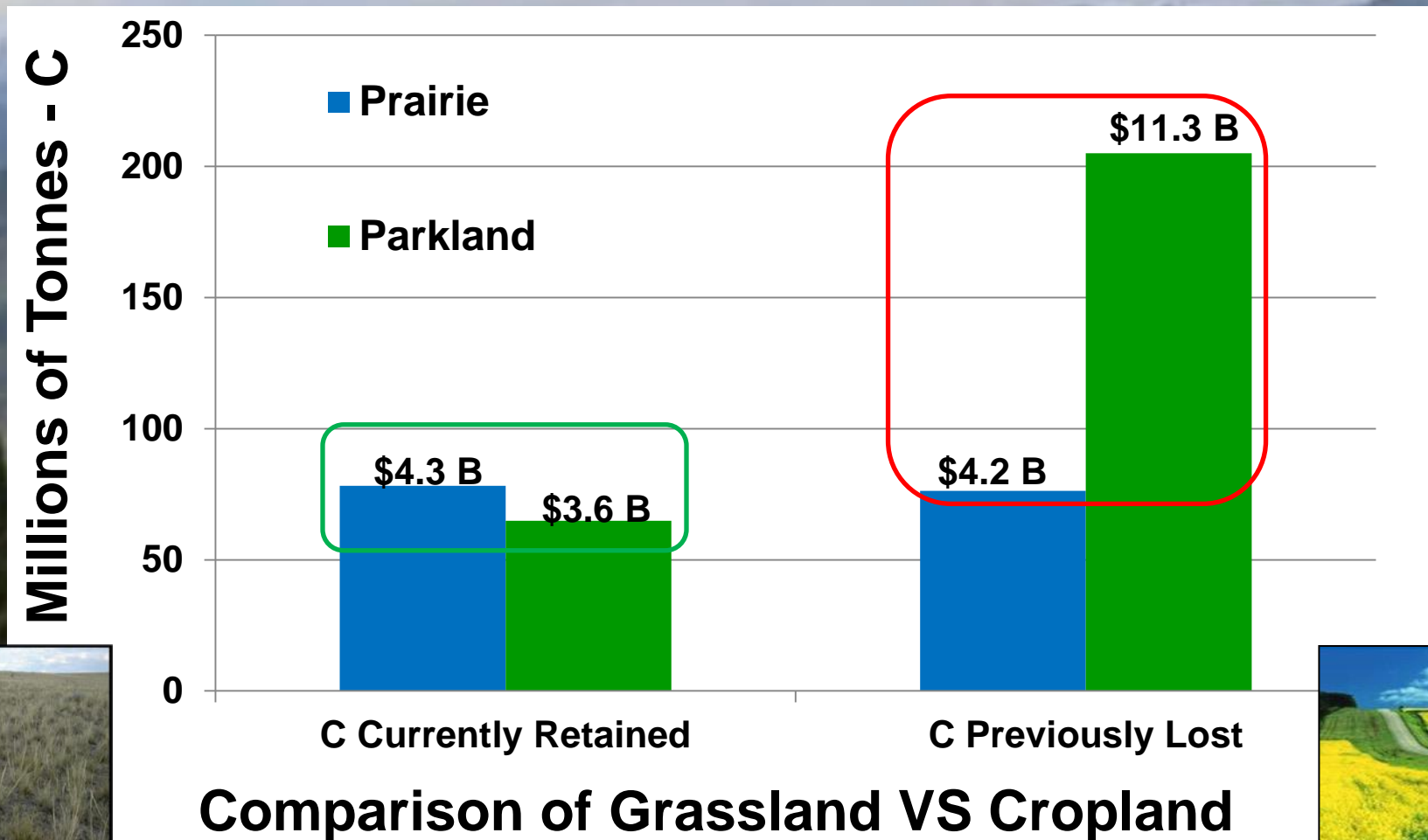
Source: Dormaar et al. (1994)

Benchmarking Study Results Also Show Large Carbon Losses with Land Use Change in Alberta



What is the Value of C Retained/Lost from Native Grasslands?

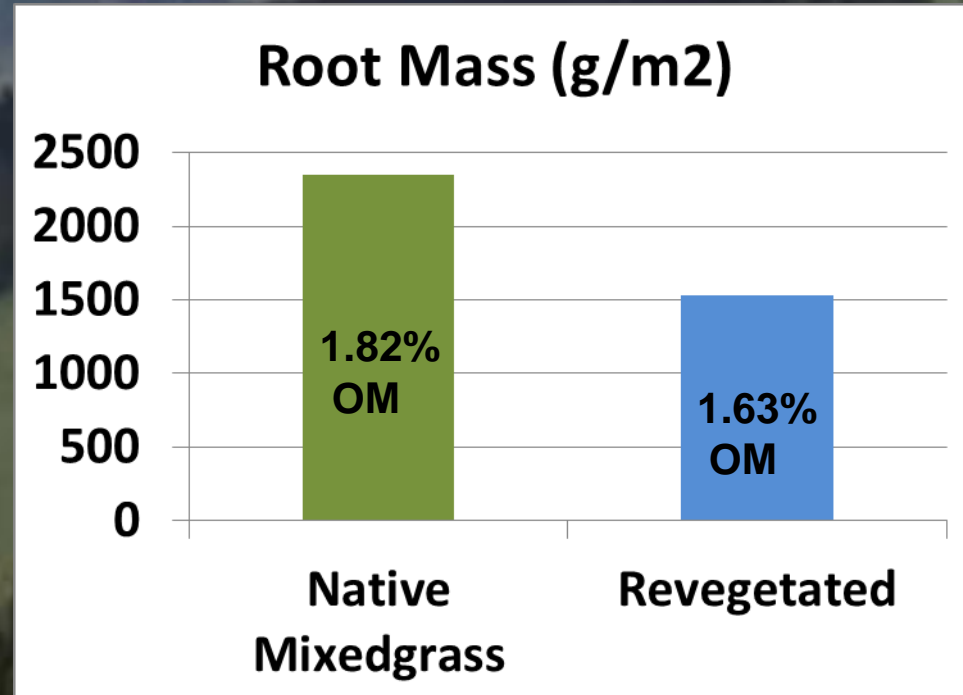
Carbon stores derived using ABMI areas for each land use change and a C-valuation of \$15/t-CO₂e (CCEMC)



How Quickly Does Carbon Recover Once Lost by Cultivation?

Naturally re-vegetated Mixedgrass Prairie failed to recover in root mass & soil OM after 50 years

- Low resilience suggests long-term opportunity costs in C storage with land use conversion



What About Grazing and Carbon?



Grazing Effects on Carbon are Inconsistent & Difficult to Predict ...



Mixedgrass under grazing

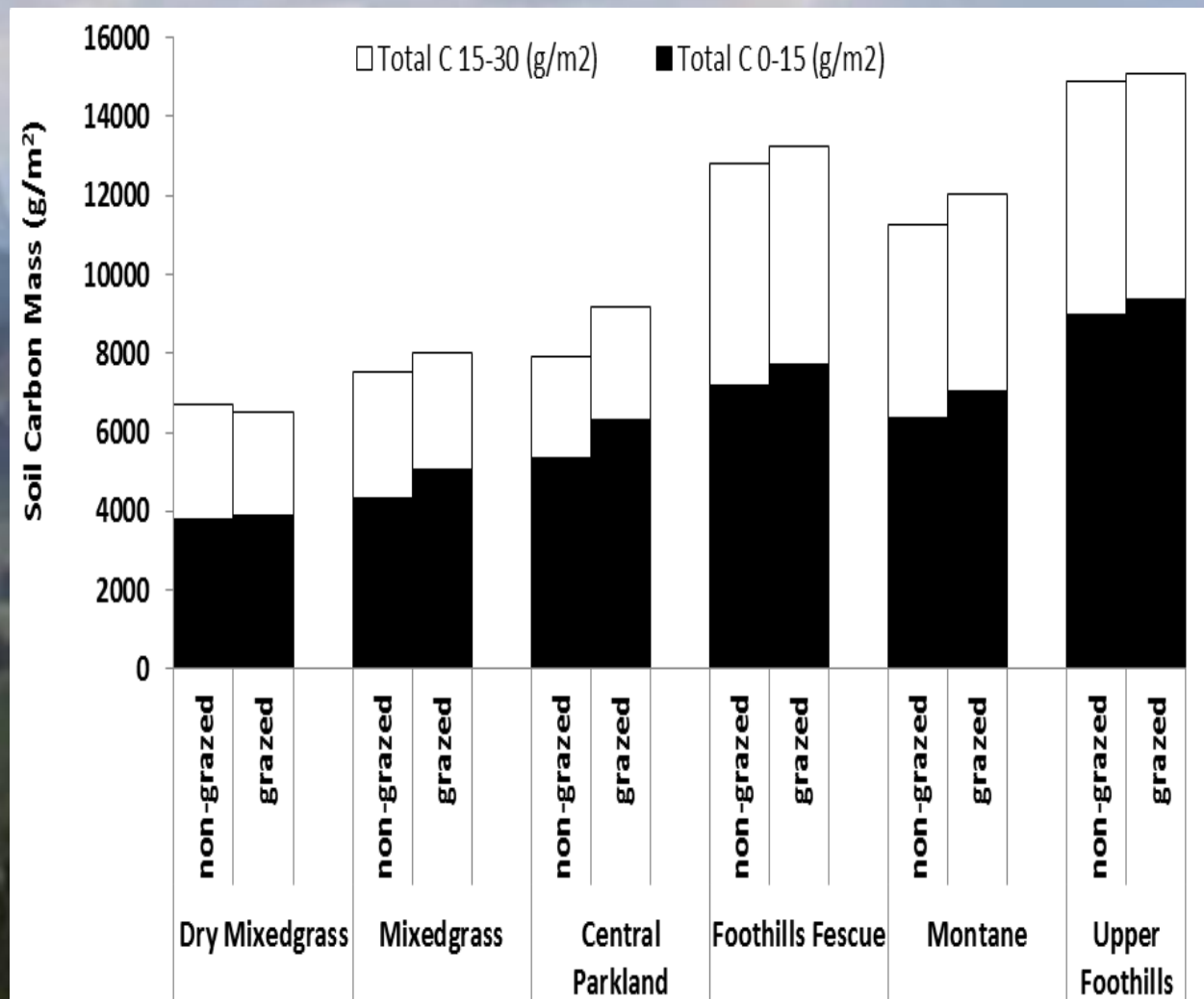


Fescue under grazing



Grazing and Ecosystem Carbon

Weak trend for greater SOC in 5 of 6 study regions:



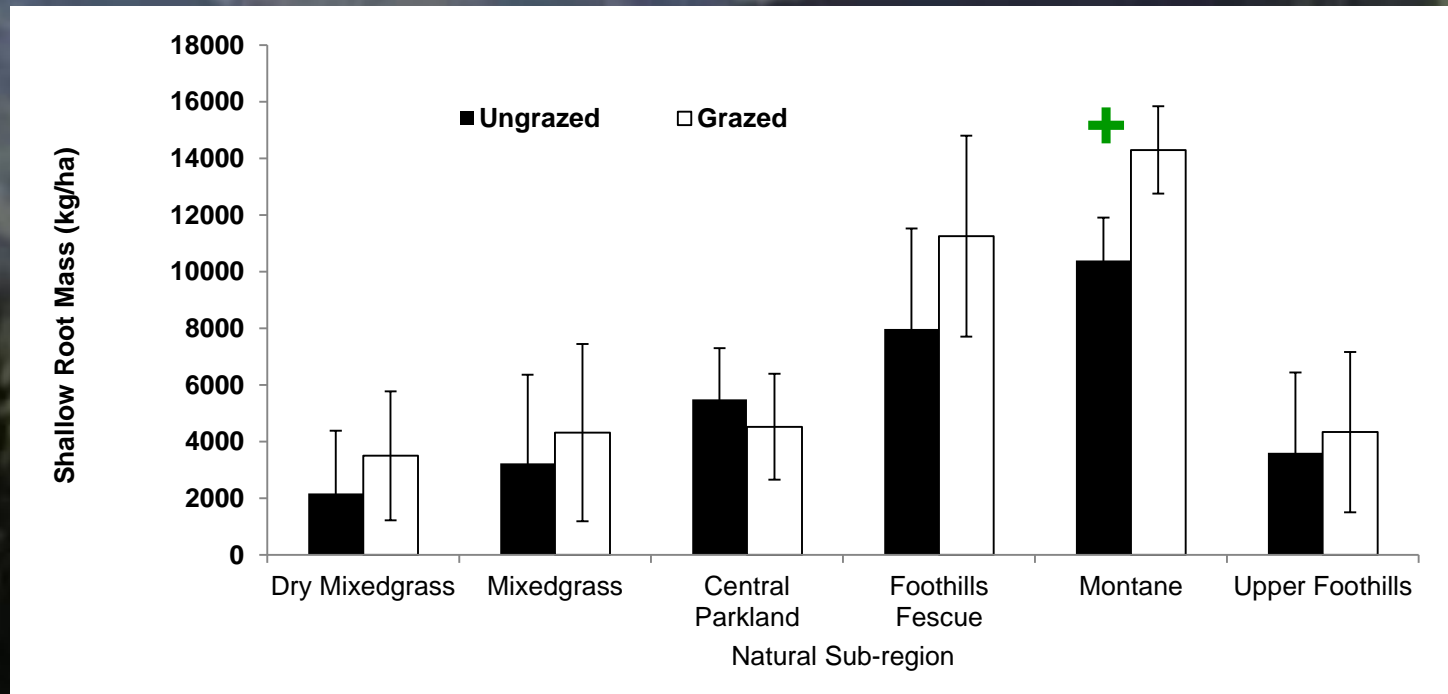
➤ Reductions in veg C (litter, mulch) under grazing were offset by increased soil C

➤ Net effect is NO CHANGE in total ecosystem C

***** Soil C is the largest pool of ecosystem C due its large mass (60 – 140 t/ha)**

Grazing Impacted Belowground Vegetation as well ...

- Grazing stimulated root production (as it did shoot biomass) in areas with favorable rainfall

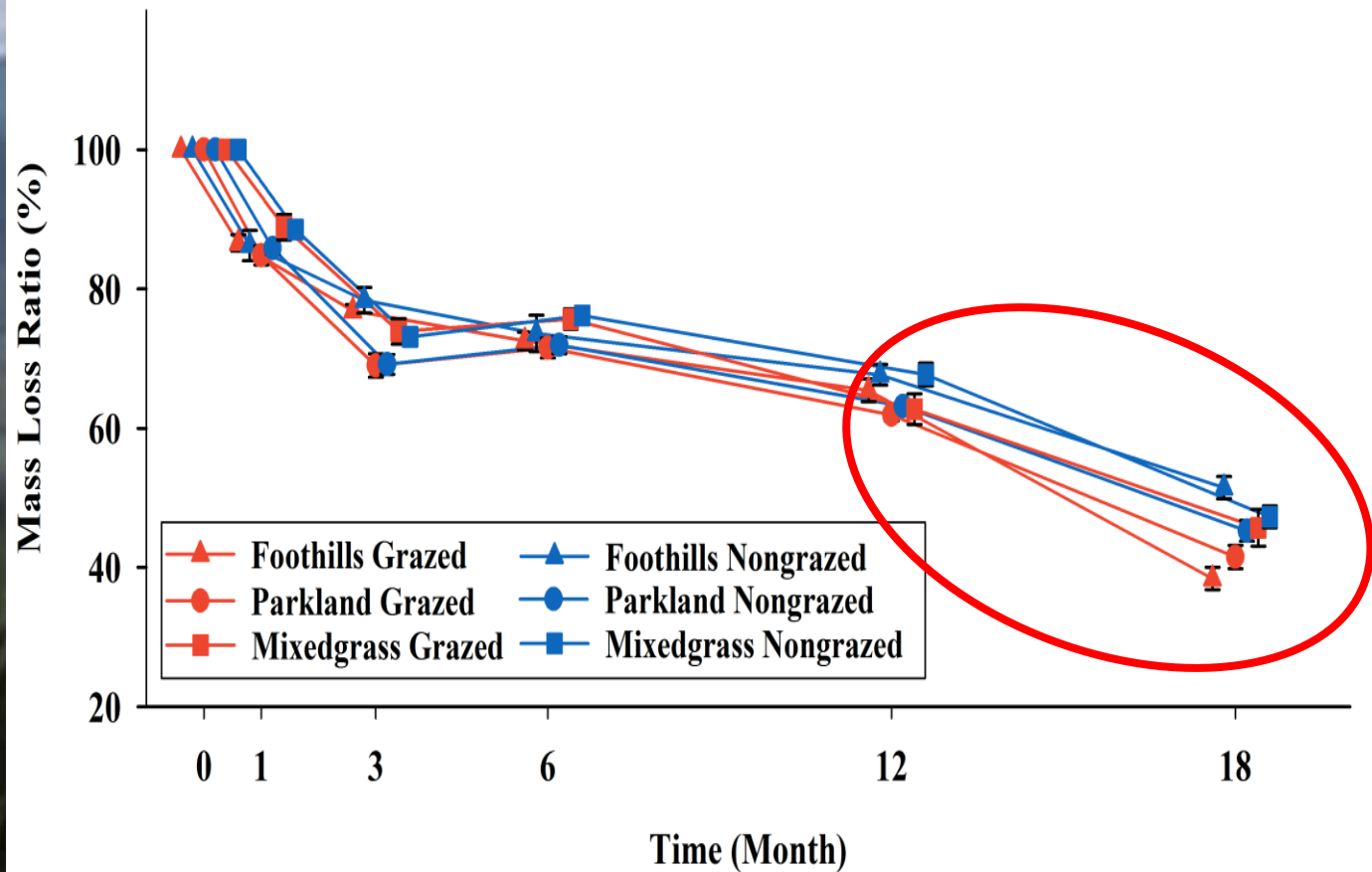


Current Studies are Linking Grazing and Microbial Activity to Litter Decomposition, Carbon Cycling, and Associated GHGs



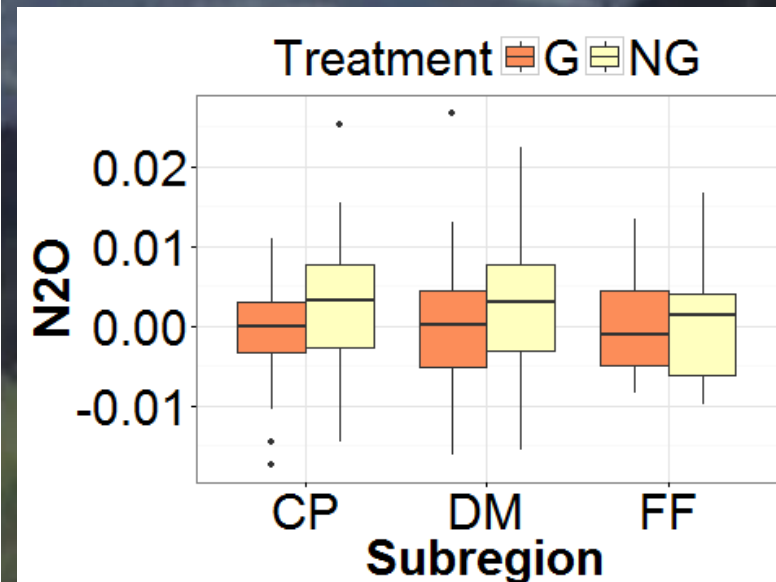
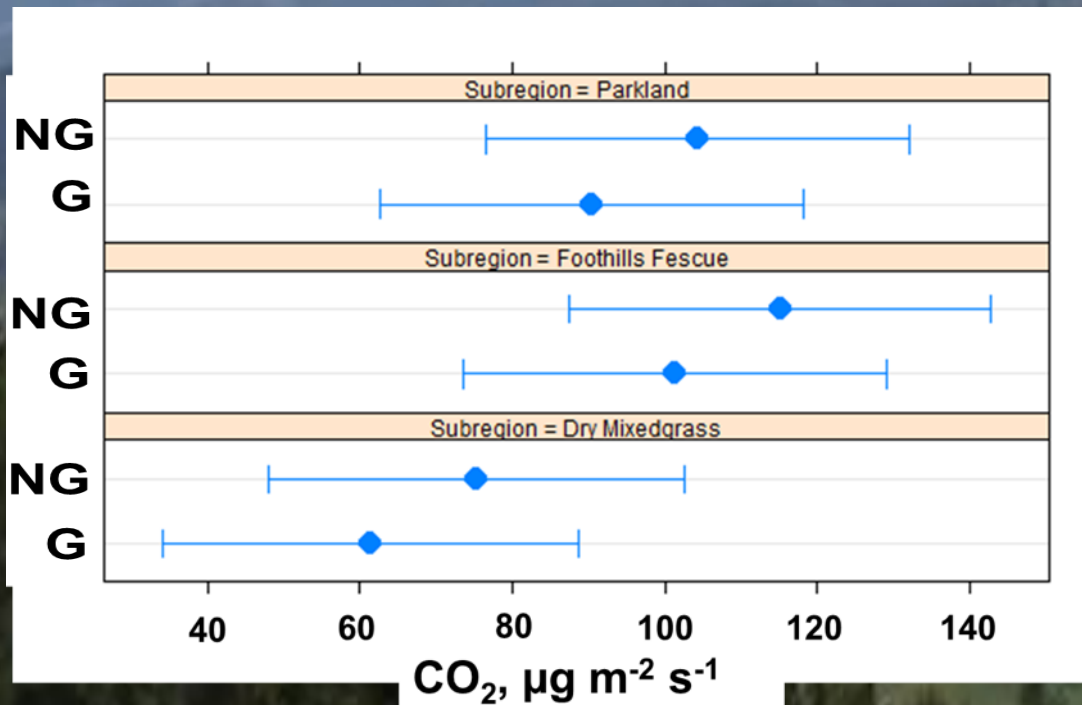
Grazing Effects on Decomposition

- After 12 months, litter decomposition was enhanced by grazing ... could this reflect greater incorporation of C into soil OM?



Comparative GHG Uptake Under Long-Term Grazing (Stolnikova, in prep.)

- No statistical differences in CO_2 / N_2O flux in relation to grazing, though both GHGs had a trend to be lower in grazed agro-ecosystems

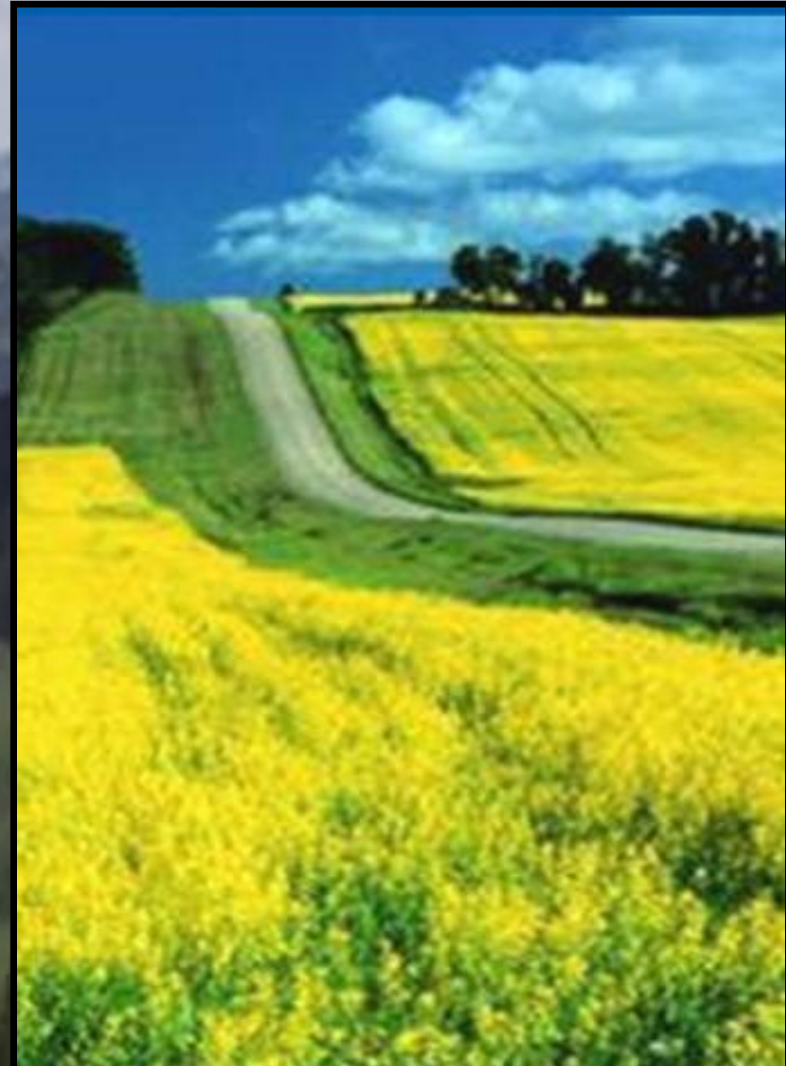


Current State of Carbon Offset Programs in Agriculture ...

Tillage Systems Protocol (2009):

- Payments for reductions in CO₂ through reduced and no-till agronomic practices (~\$1 per acre)
- Largely ephemeral policies that could change

Source: van Kooten (2006)



Policy Implications for Carbon Storage in Grasslands ... ???

- 1) Currently no incentives for maintaining C in existing native grassland
- 2) This is despite greater C levels and more favorable soil health



GOA is Working on Policies to Value Grassland Carbon Stores

(Regulated offsets + Voluntary market)



Take Home Messages

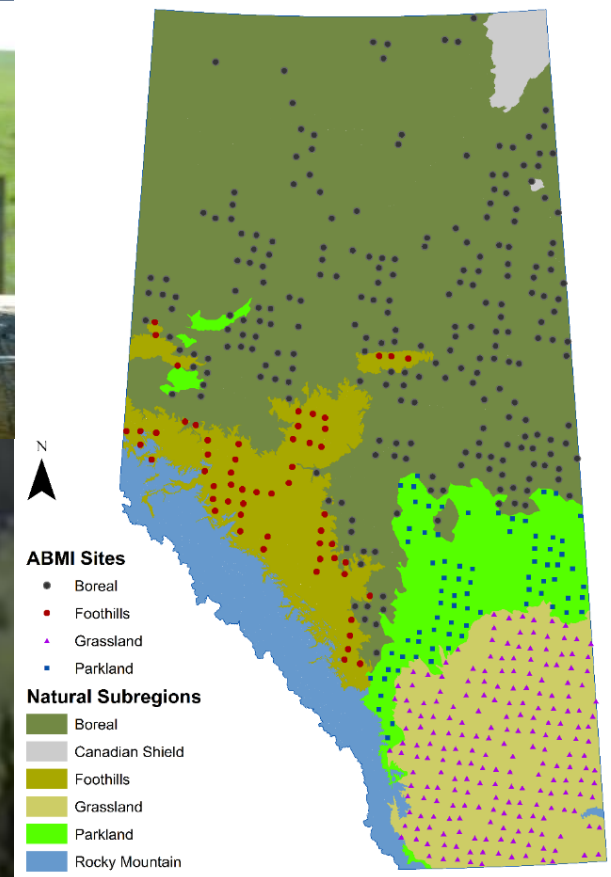
- **Native grasslands provide abundant EG & S in comparison to croplands (i.e. C storage, improved soil health, greater pollination, GHG uptake), with work underway to develop policies valuing this service**
- **Moderate grazing can enhance some EG & S, including plant diversity and forage production, and maintain C**



'Beef & Biodiversity'



Goal is to directly link comprehensive biodiversity data with cattle producer management practices at ~200 sites across Alberta



Grassland as Key Habitat for Pollinators (Drs. C. Carlyle & J. Manson)

- Work to date has found over 180 different species
- Bee abundance and diversity were positively related to floristic richness, range health and forage quality



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