Overview of Grassland Research:
EG&S, Carbon & Drought

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Alberta Forage Industry Network

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Brief Outline

- Main findings of recent ALMA grassland benchmarking study
- Decomposition studies to assess grazing impacts on carbon accumulation + GHG emissions
- Climate change impacts on Canadian grasslands + new project underway

EG & S: “Benefits all of society receive from the existence of grasslands”

Water Purification/Flood Mitigation

Carbon Storage

Pollination

Forage Production

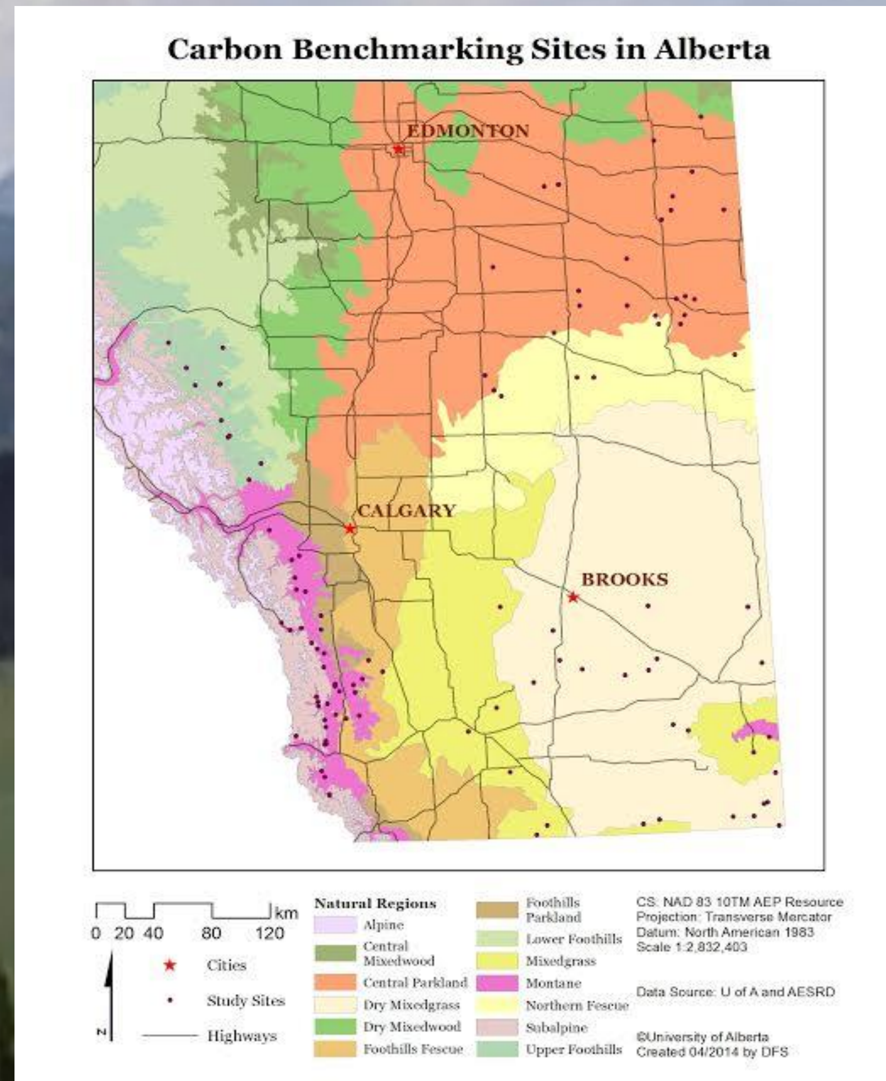
Wildlife Habitat

Rangelands and EG & S:

Recent findings of a University of Alberta/AEP Collaboration

ALMA
Alberta Livestock and Meat Agency Ltd.

- Sampled 114 grasslands managed by Alberta Environment & Parks

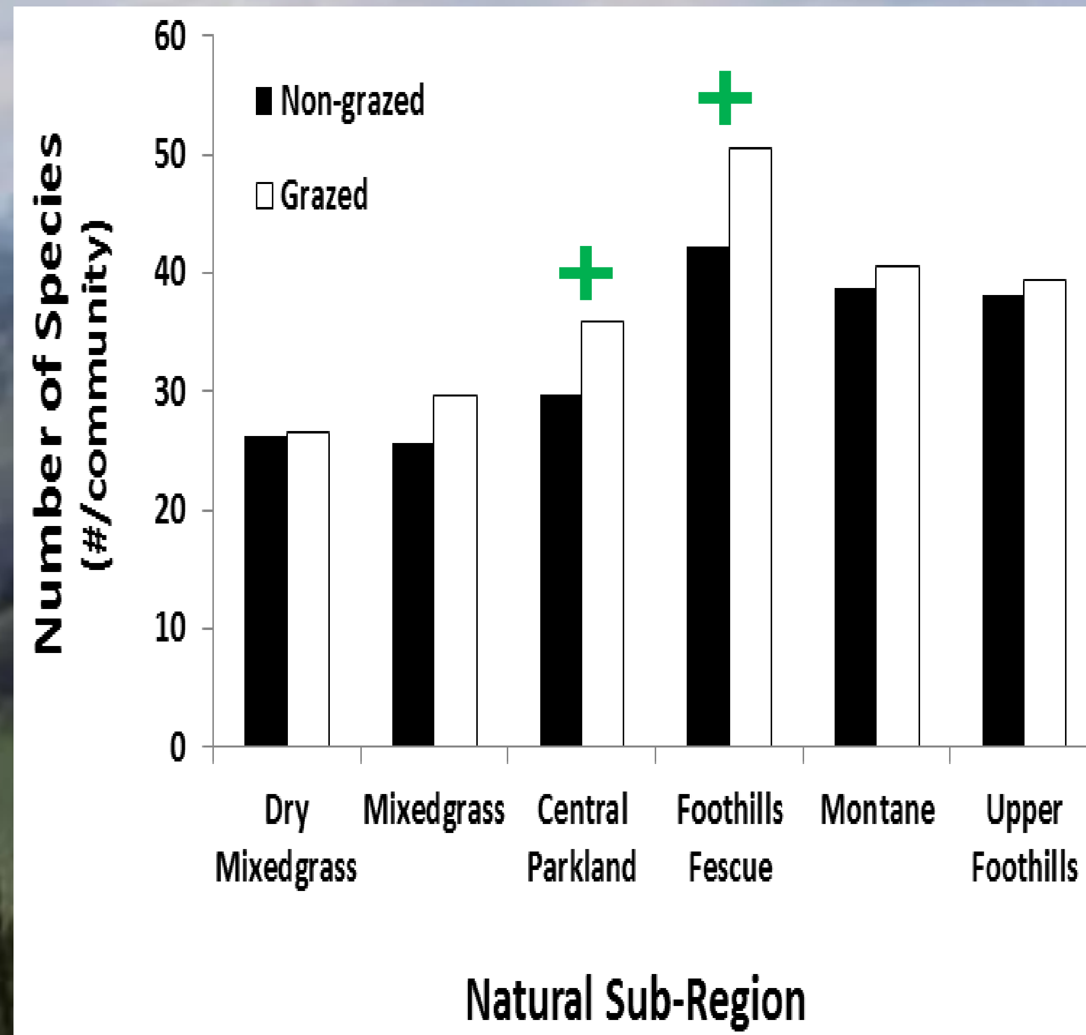


Quantified Various EG & S

- Examined exclosures (15-70 yr old)
- Enabled long-term assessment of presence/absence of livestock grazing
- Measured biomass, plant diversity & carbon stores

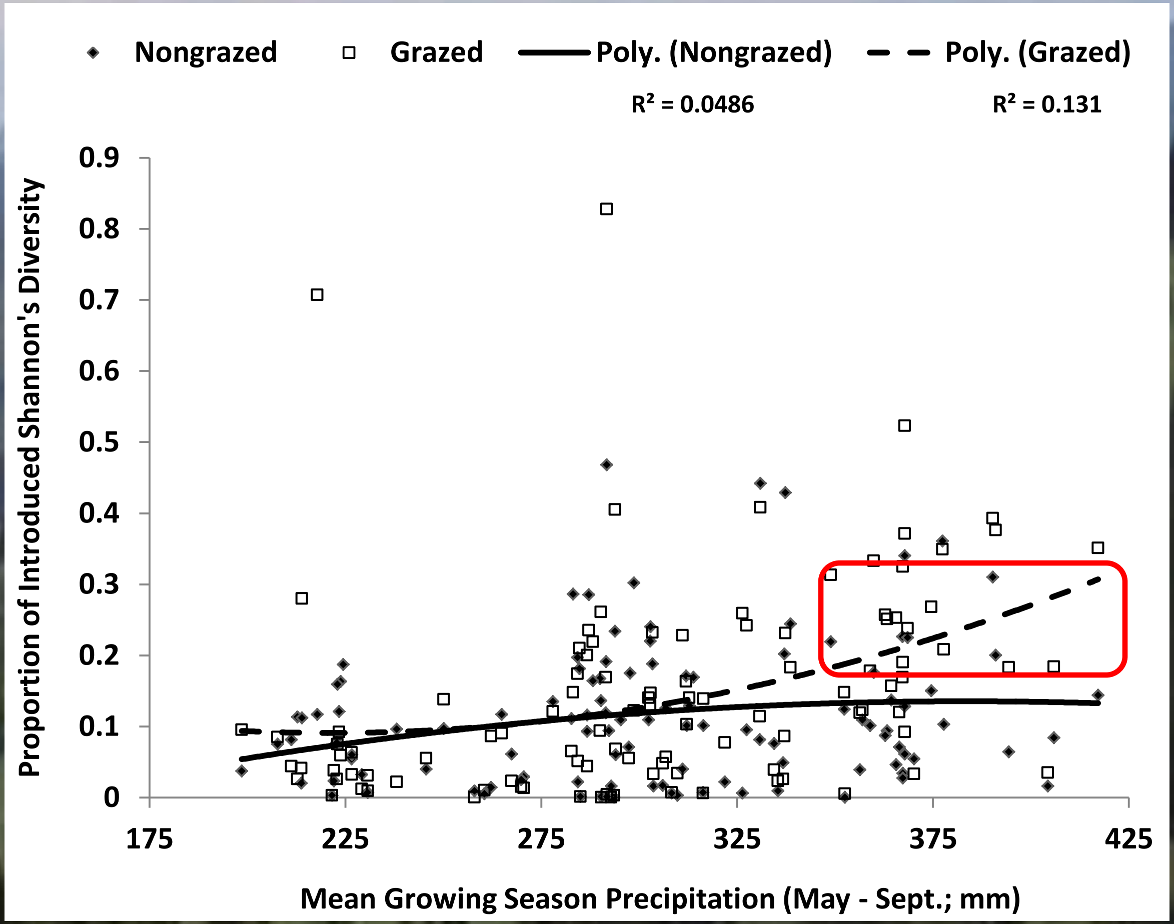
Grazing & Biodiversity

- 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 were in Parkland and Foothills Fescue



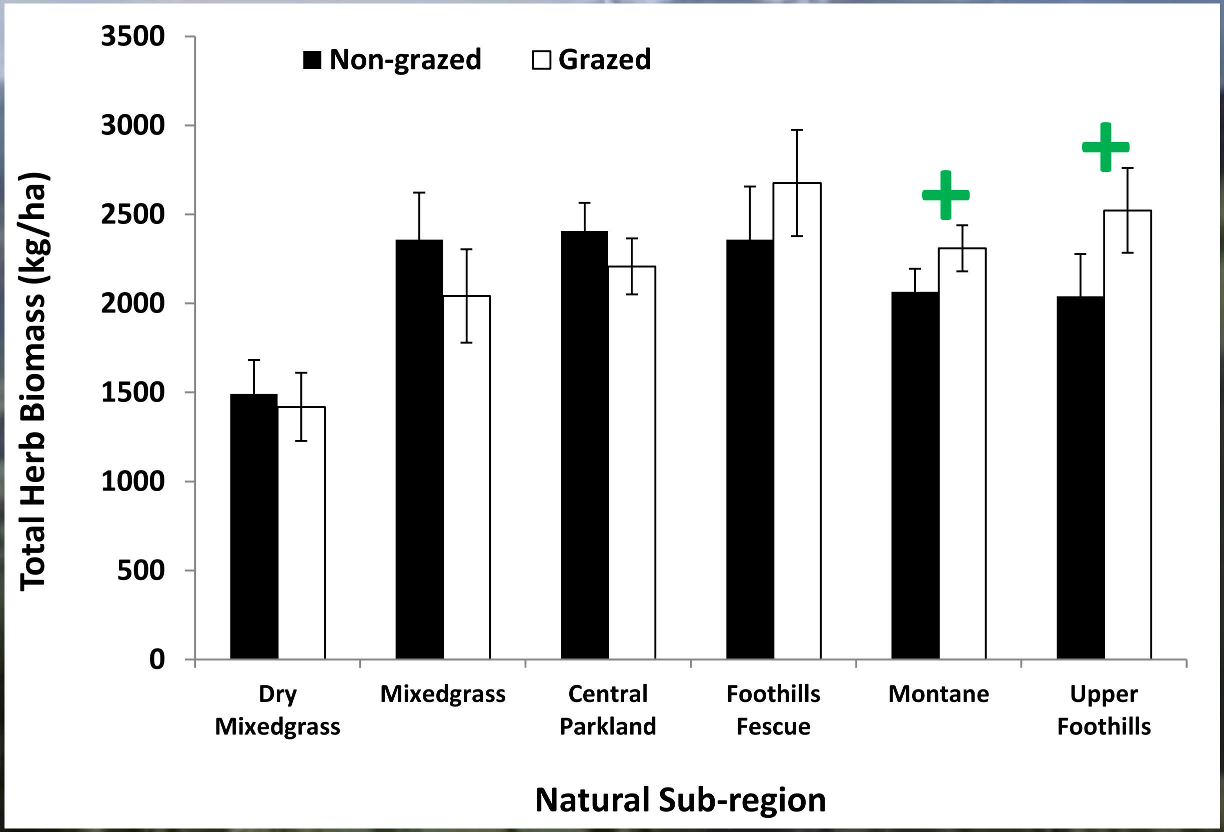
Does Grazing Alter Introduced Plant Species?

- **Introduced species increased with rainfall**
- **Semi-arid grasslands with < 350 mm (14") had greater resistance to invasion**
- **Grazing facilitated the increase of introduced spp. - but only under moist conditions**



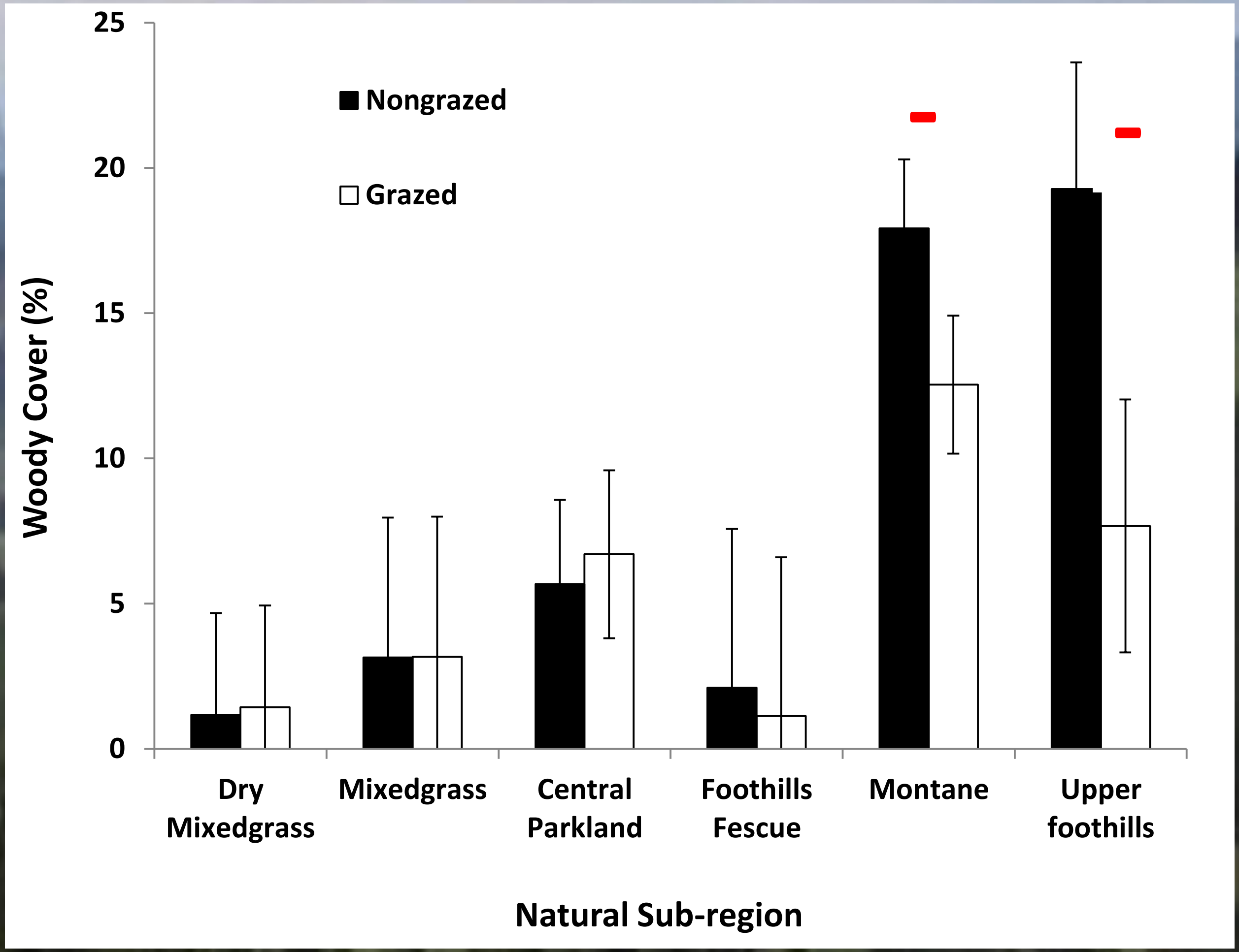
Grazing Impacts on Grassland Herbage Productivity

- Grazing enhanced production in high rainfall grasslands of SW Alberta
- Introduced species likely play a role in boosting herbage productivity!



Grazing May Help Limit Shrub Encroachment

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



Rangelands & Carbon Storage

(Mitigation of Rising CO_2 Levels – “Greenhouse Effect”)

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

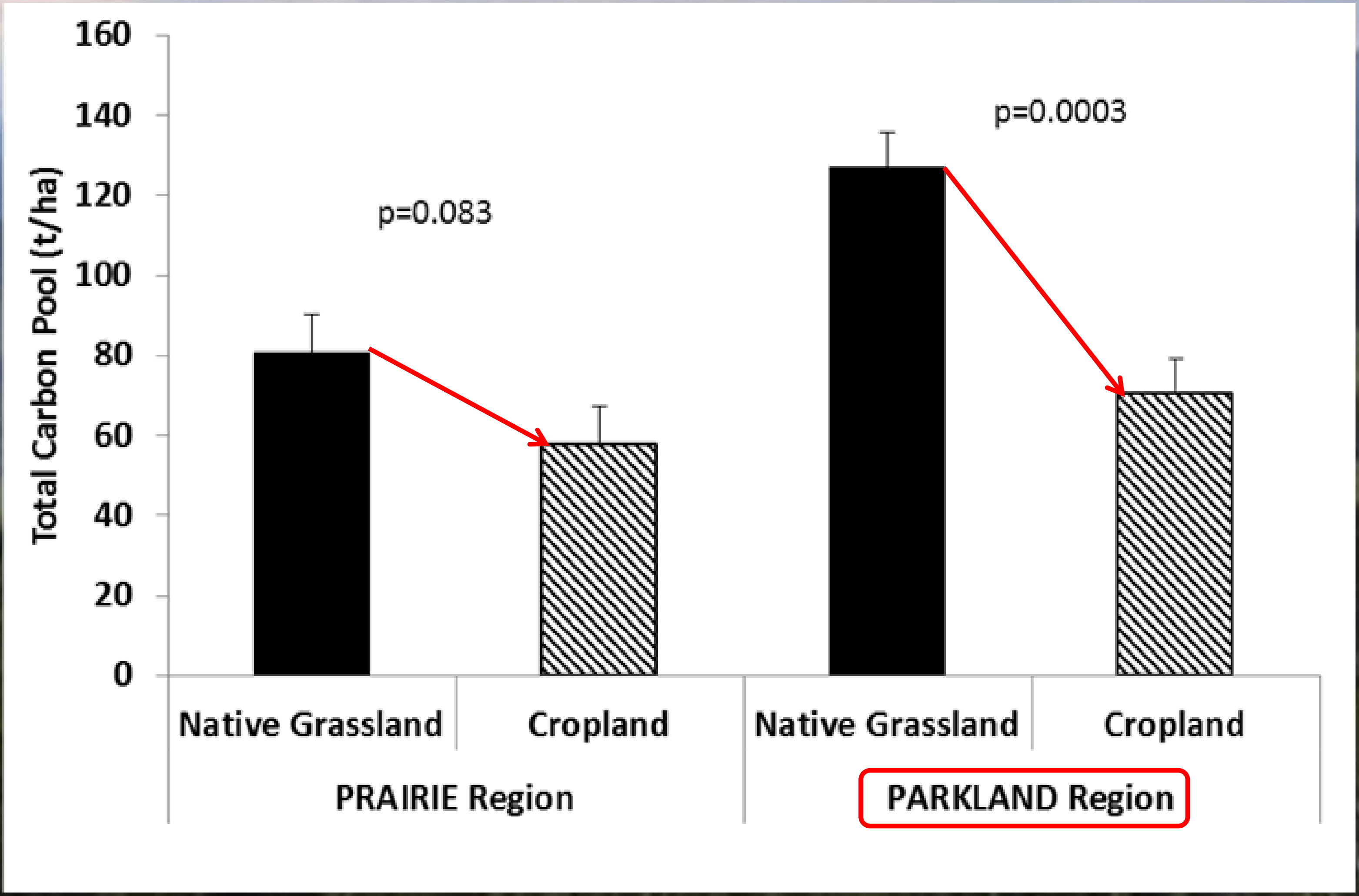
Temperate grasslands (~8% of earth’s surface) contain more than 300 Gt C:

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

Sources: Schuman et al. (2002); Lal (2002); IPCC (2000)

Carbon Losses Under Competing Land Uses Across Alberta

(Benchmarking Study)



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

Summary of the amount (Mt) and value ($ B) of C retained and lost from native grasslands relative to alternative land uses in Alberta. Results are stratified by the Prairie and Parkland, with values derived from mean C differences observed within each region. Masses of C associated with the each value are shown in parentheses. Carbon is valued at $15/t - CO_2 e (equivalence). Areas[1] of each land use were obtained courtesy the Alberta Biodiversity Monitoring Institute.

Carbon Pool	Prairie Region		Parkland Region	
	C Currently Retained in Native Grassland			
	vs Cropland	*vs* Intro. Forage	*vs* Cropland	*vs* Intro. Forage
TOTAL C - mass	78.217 Mt	102.156 Mt	64.934 Mt	35.749 Mt
value	$ 4.30 B	$ 5.61 B	$ 3.56 B	$ 1.96 B
	C Potentially Lost from Past Native Grassland Conversion			
	To Cropland	To Introd. Forage	To Cropland	To Introd. Forage
TOTAL C - mass	76.318 Mt	13.494 Mt	204.997 Mt	32.955 Mt
value	$ 4.19 B	$ 0.74 B	$ 11.25 B	$ 1.81 B

[1] Areas of grassland, introduced forage and cropland in the Prairie (Dry Mixedgrass, Mixedgrass and Foothills Fescue combined) were 3.396319, 0.448629, and 3.313839 M ha, respectively. Areas of grassland, introduced forage and cropland in the Parkland (Northern Fescue, Central Parkland and Foothills Parkland combined) regions were 1.143926, 1.054508, and 3.611383 M ha, respectively.

Land Use Conversion Also Reduced Soil Health

NG had Improved Metrics of Soil Quality!

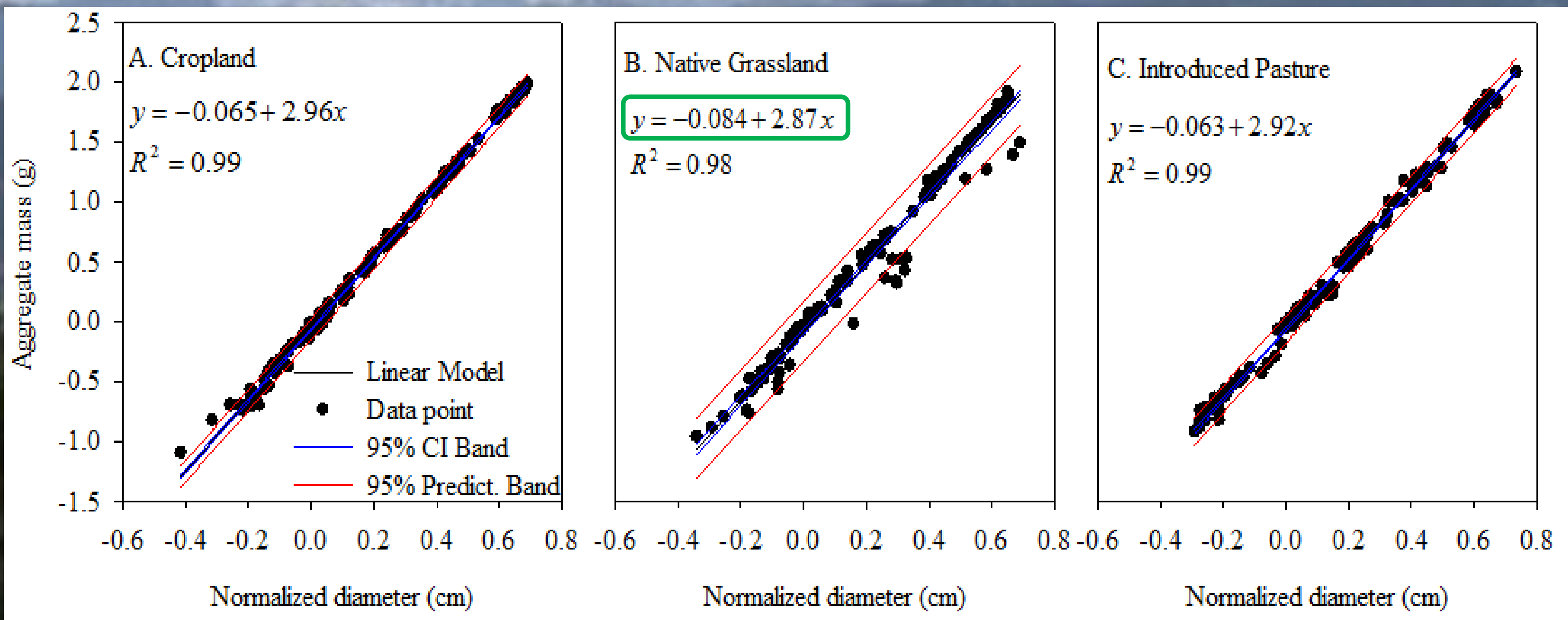
LAND USE	Max Water Availability ($cm^3\ cm^{-3}$)	Soil Porosity	S-index
Native Grassland	0.14^{b}	0.54^{b}	0.048^{b}
Introduced Pasture	0.099^{a}	0.46^{a}	0.033^{ab}
Annual Cropland	0.096^{a}	0.47^{a}	0.020^{a}

Max water availability is the difference between field capacity and wilting point; S-index is the maximum slope of the water retention curve, with a greater slope indicative of greater water delivery with increasing moisture stress.

Source: Unpublished data

Land Use Conversion Impacts on Soil Aggregation

Lower Fractal Mass (Dm) = Improved Aggregation



Source: Unpublished data

What About Grazing and Carbon?

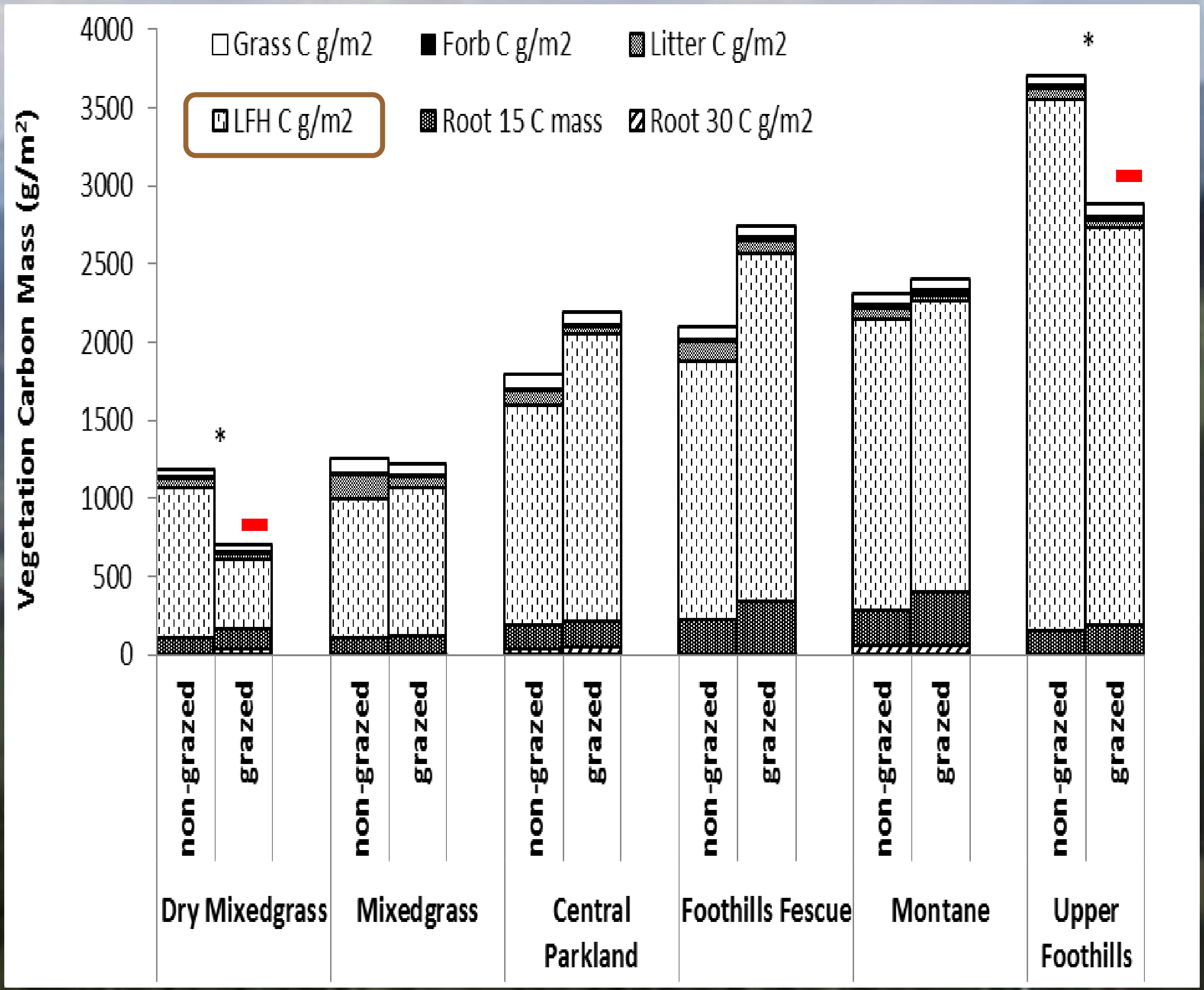
Grazing Effects on Total Carbon are Inconsistent & Difficult to Predict …

Mixedgrass under grazing

Fescue under grazing

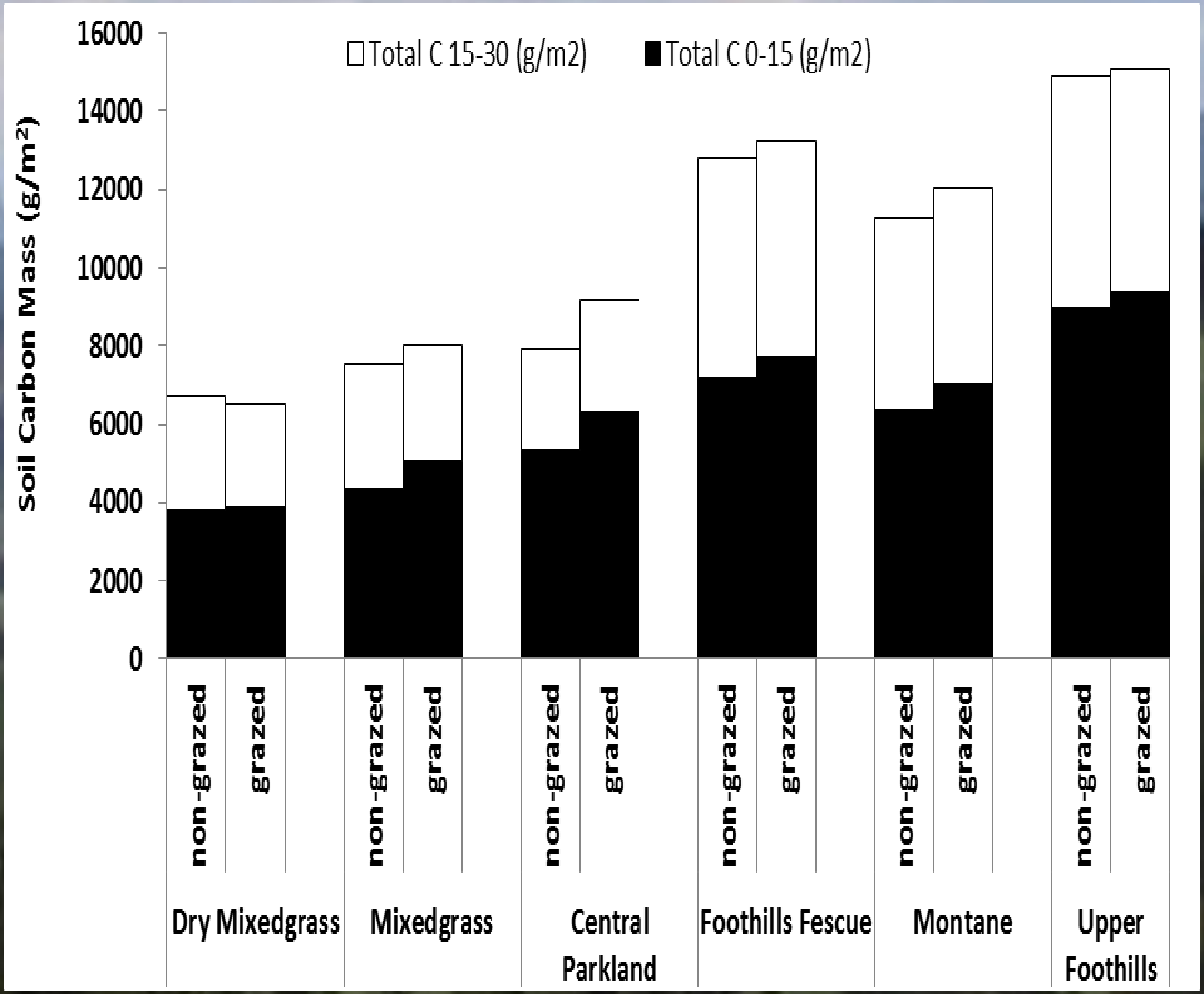
Grazing Impacts on Veg'n Carbon
(Benchmark Study)

- Grazing reduces the size of above-ground vegetation C pools
- Largest decline is in the surface mulch layer



Grazing and Soil Carbon

Note trend for greater SOC in 5 of 6 regions:

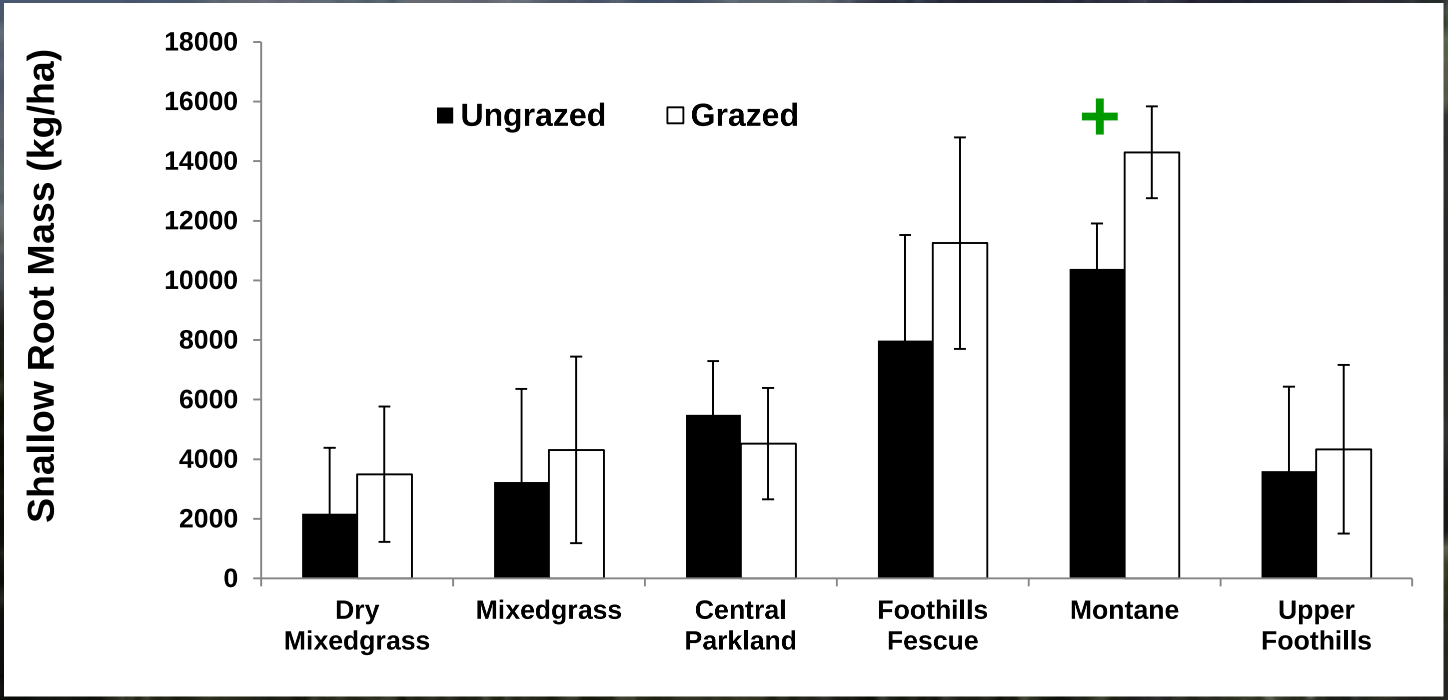


- **Reductions in veg C (litter, mulch) are offset by consistent increases in soil C**

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

Grassland Carbon Responses to Grazing May be Linked to Production

- Grazing stimulated root production (parallel to shoot biomass)



Policy Implications for Carbon Storage in Grasslands … ???

1) Maintain existing native grassland …

2) Convert marginal cropland to grassland …

3) Explore how grazing mechanistically increases C stores …

Nutrient Cycling Studies

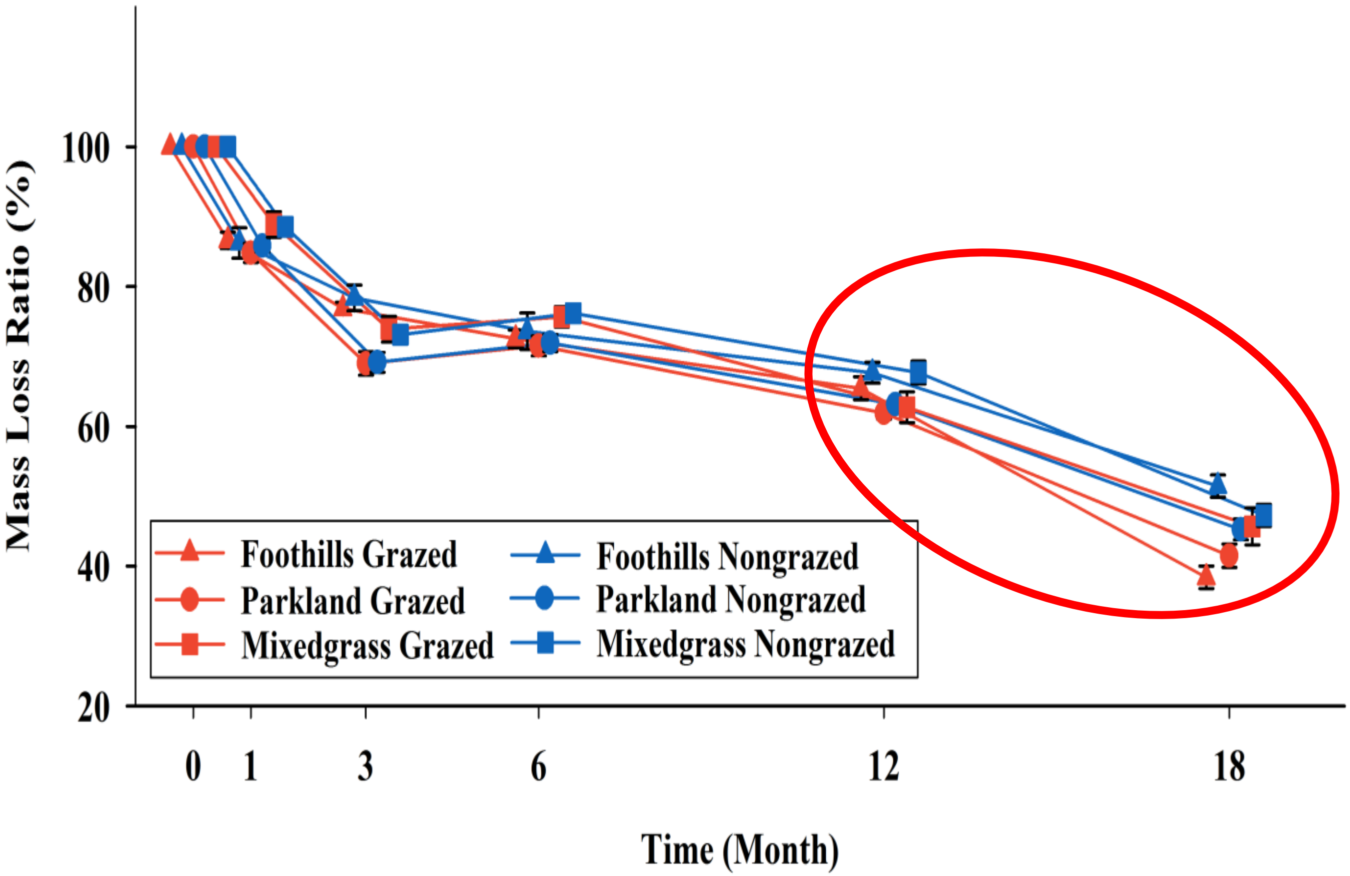
Collecting litter in the fall

Litterbag filled with grass placed in the field

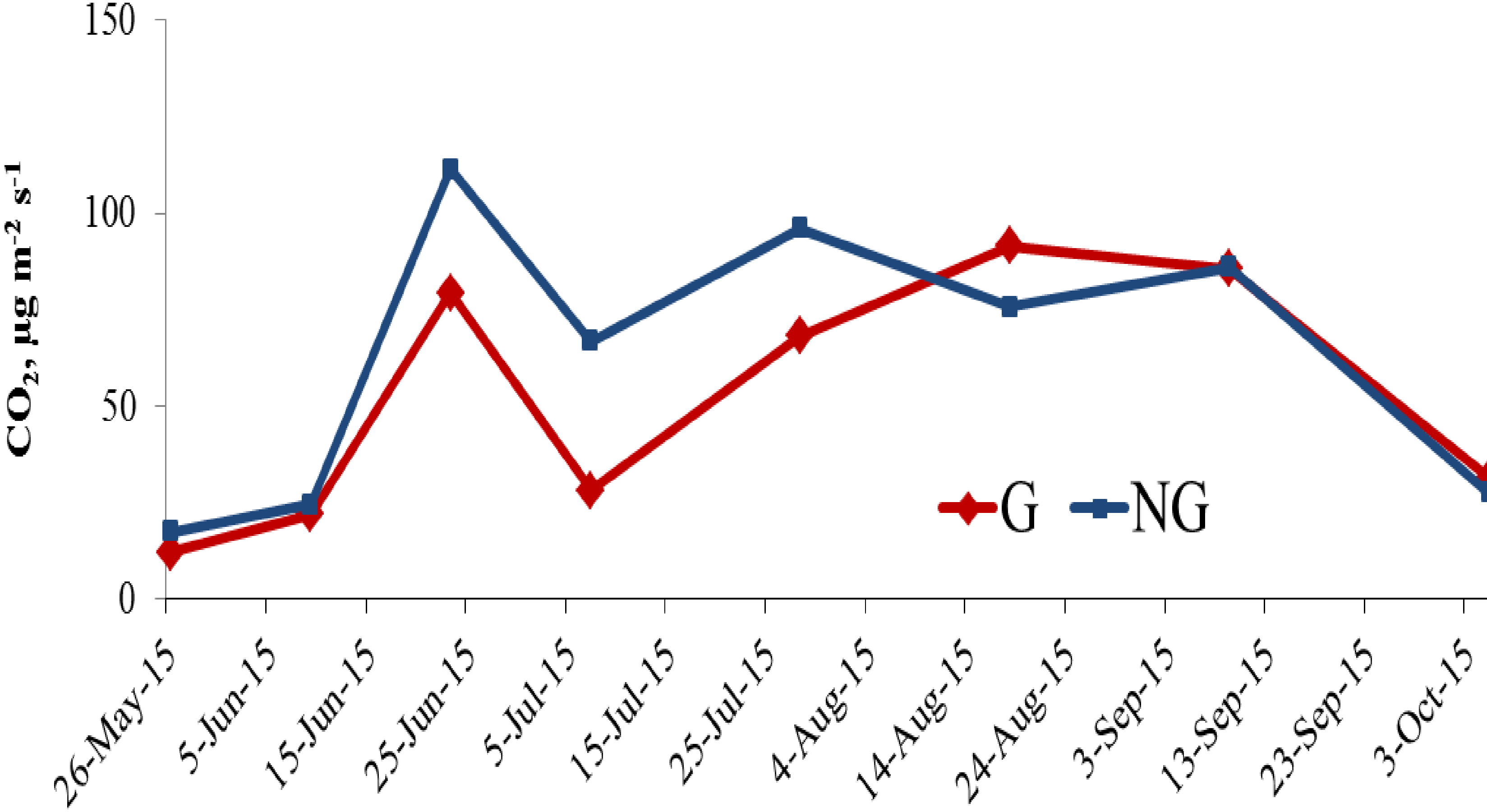
Sample soils to measure *in-situ* belowground processes

Grazing Effects on Decomposition

- After 12 months, litter decomposition was enhanced by grazing



Preliminary Results: Lower CO_2 Emissions From Soil in Grazed Areas



Could Grazing-Induced Changes in Plant Species Alter Carbon Cycling?

Foothills rough fescue ↓ Grazing tolerance

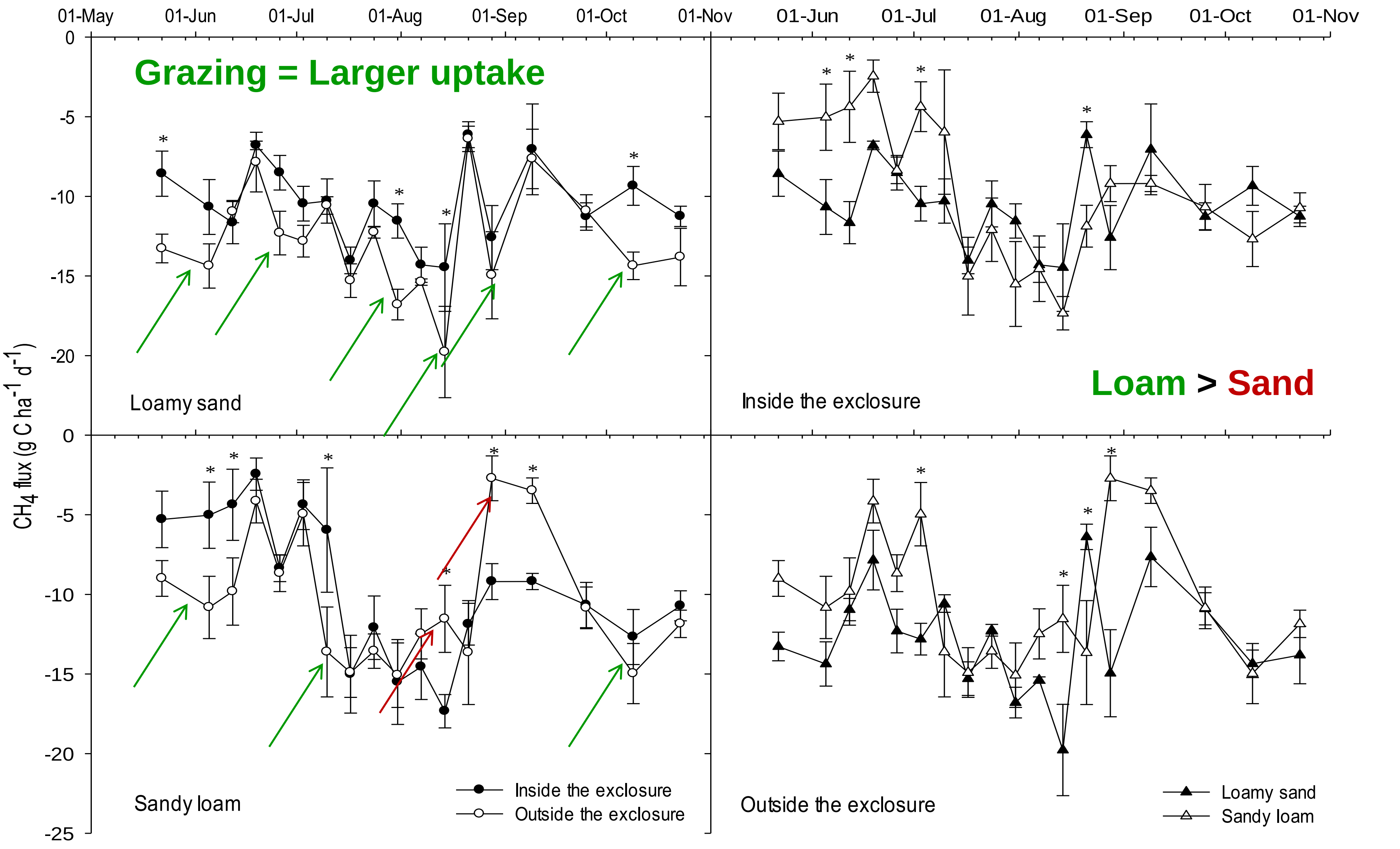
→

<u>Change in litter quality</u>

Kentucky bluegrass ↑Grazing tolerance

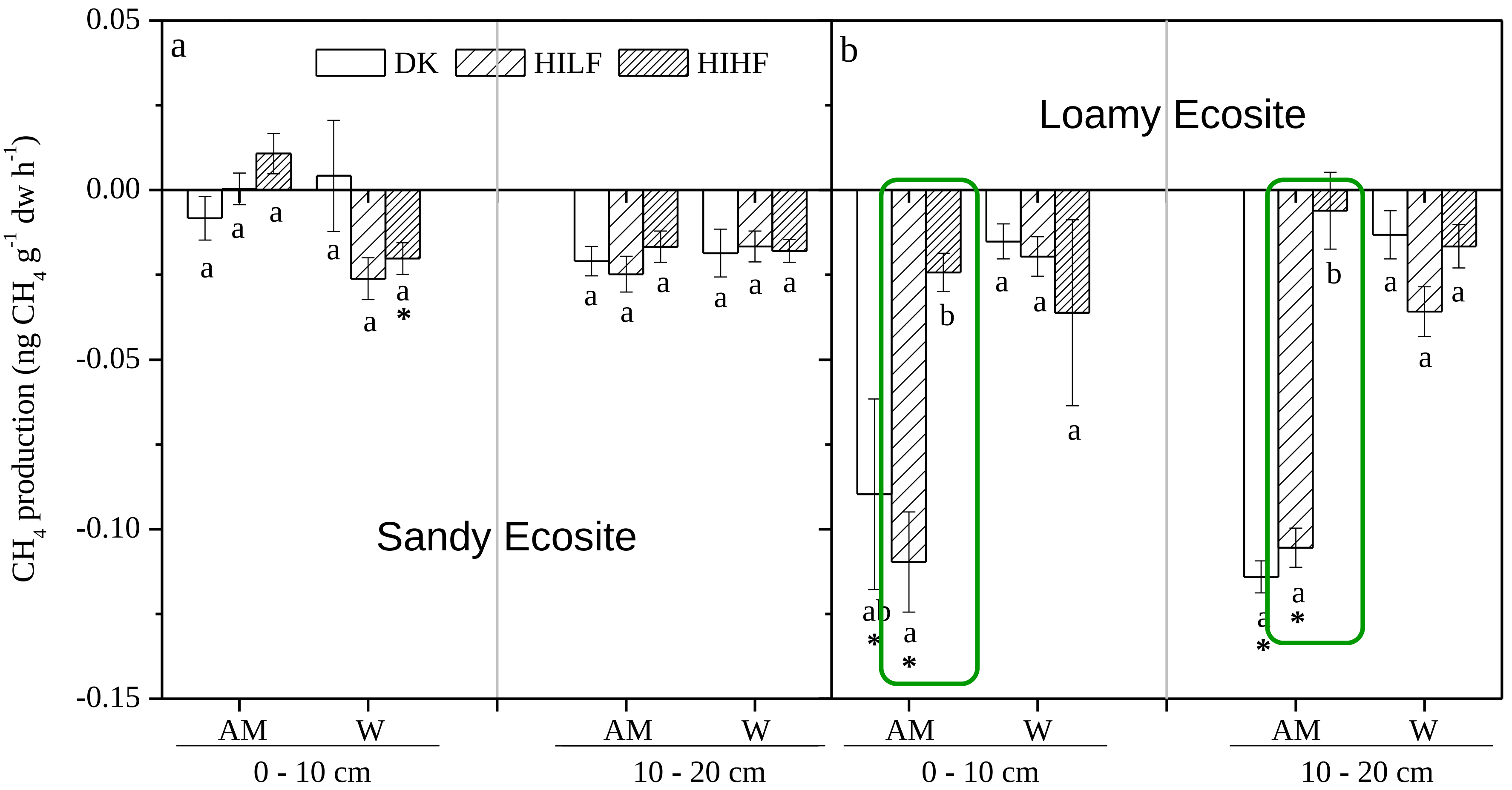
Adams et al. 2005; Dormaar et al. 1972

In-situ CH_4 Uptake in Rested & Rotationally Grazed MGP (Gao et al., in prep; 2014 data)



CH_4 Production in Soil Removed From Different Defoliation/Moisture Treatments

Source: Wang et al. (in prep); 2013 data; Lab incubations

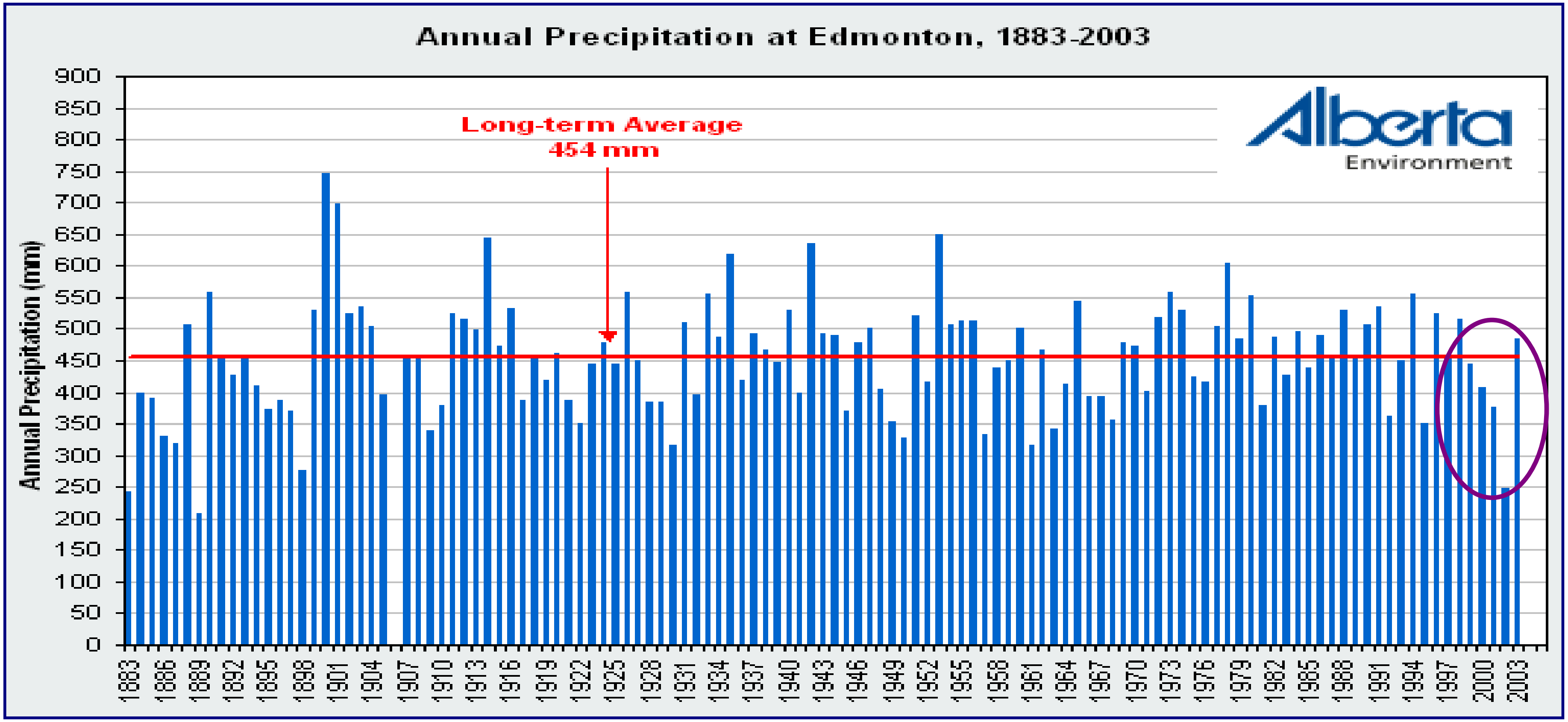


UPTAKE: **High Intensity–Low Frequency** > **High Intensity-High Frequency**

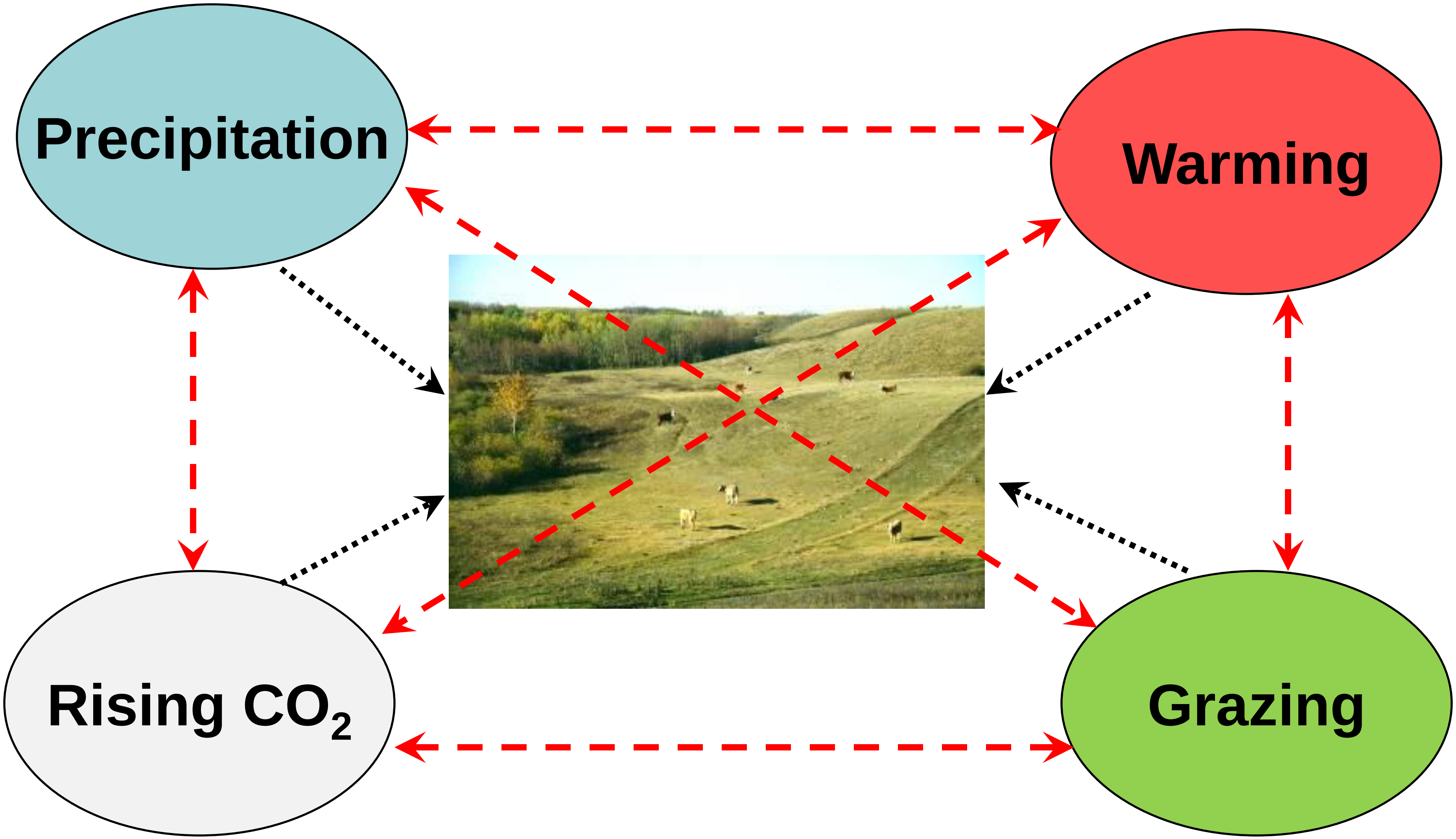
Impacts of Climate & Defoliation on Grassland Function

Why Assess Climate Change?

Climate has always fluctuated, and will continue to do so in the future



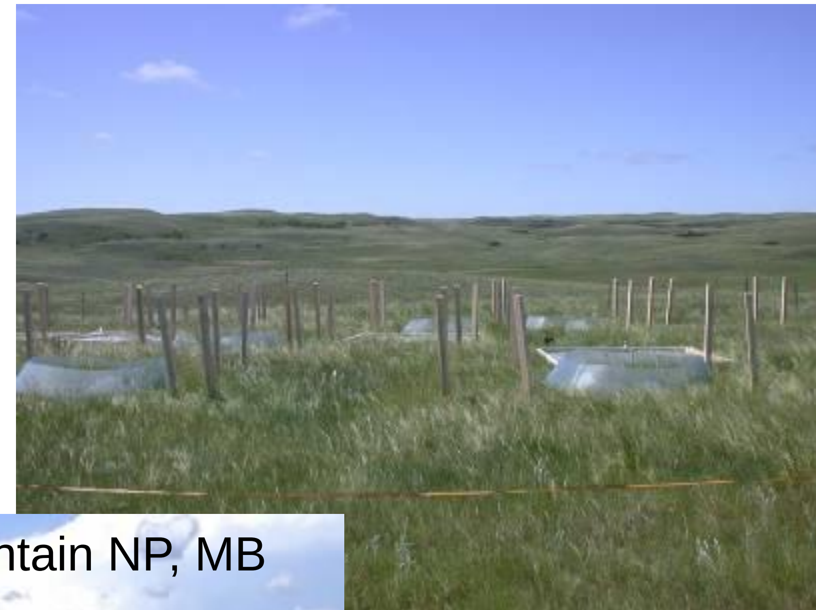
Climate x Defoliation Interactions …



Field Sites (3 Prairie Provinces)

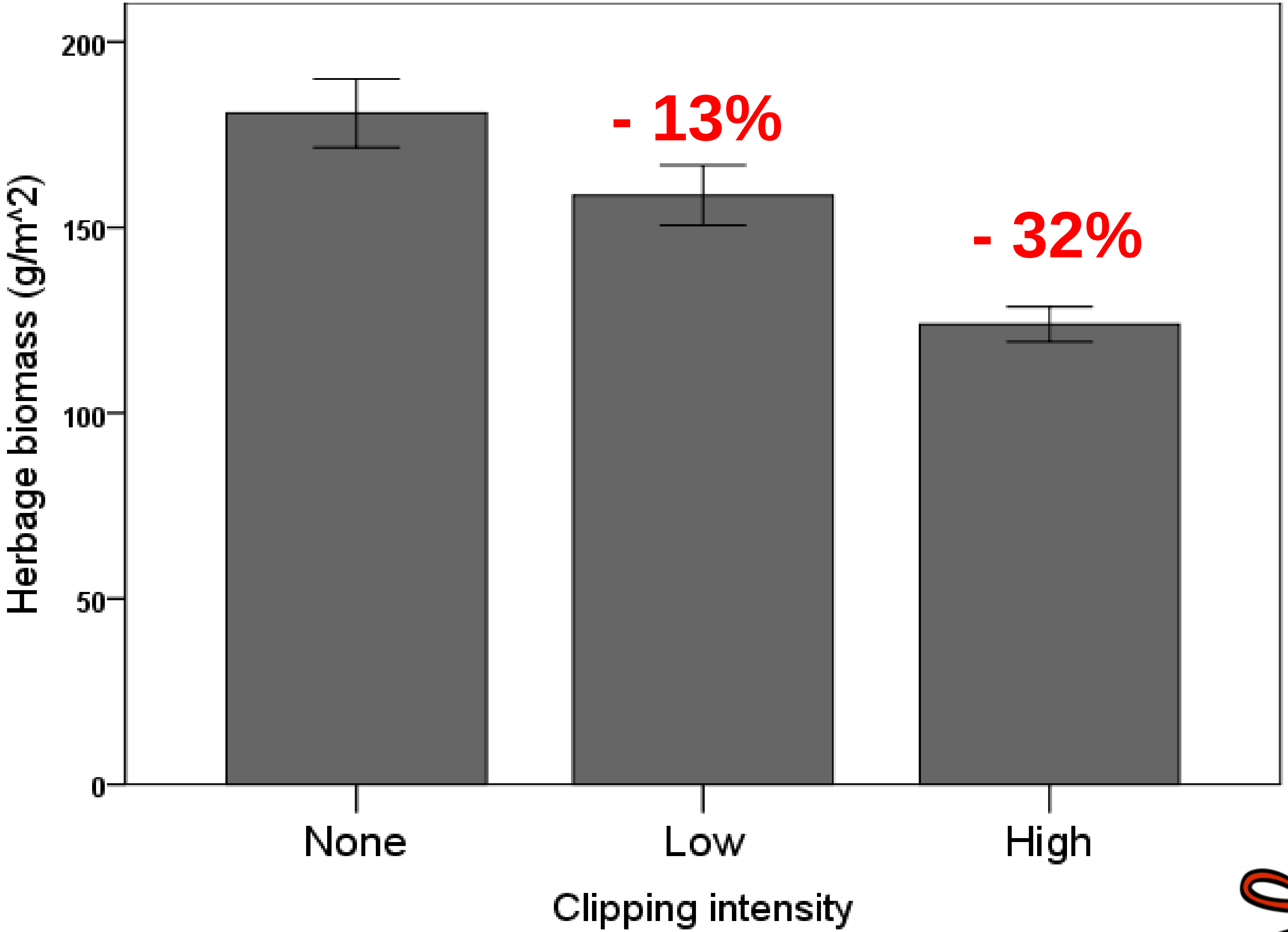
Kinsella, AB

PFRA GAP Community Pasture, SK



Riding Mountain NP, MB

Excessive Defoliation Reduces Production



Root Length Responses to Defoliation

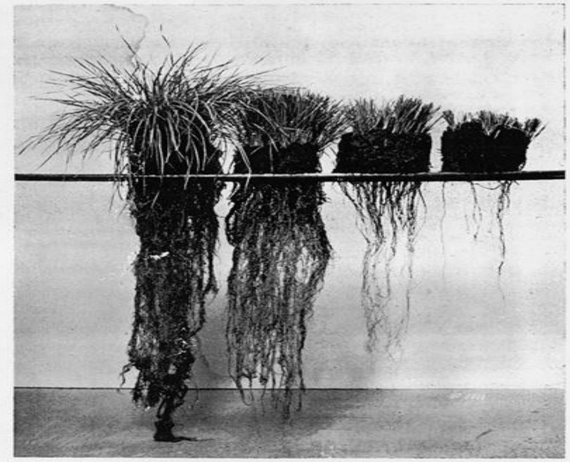
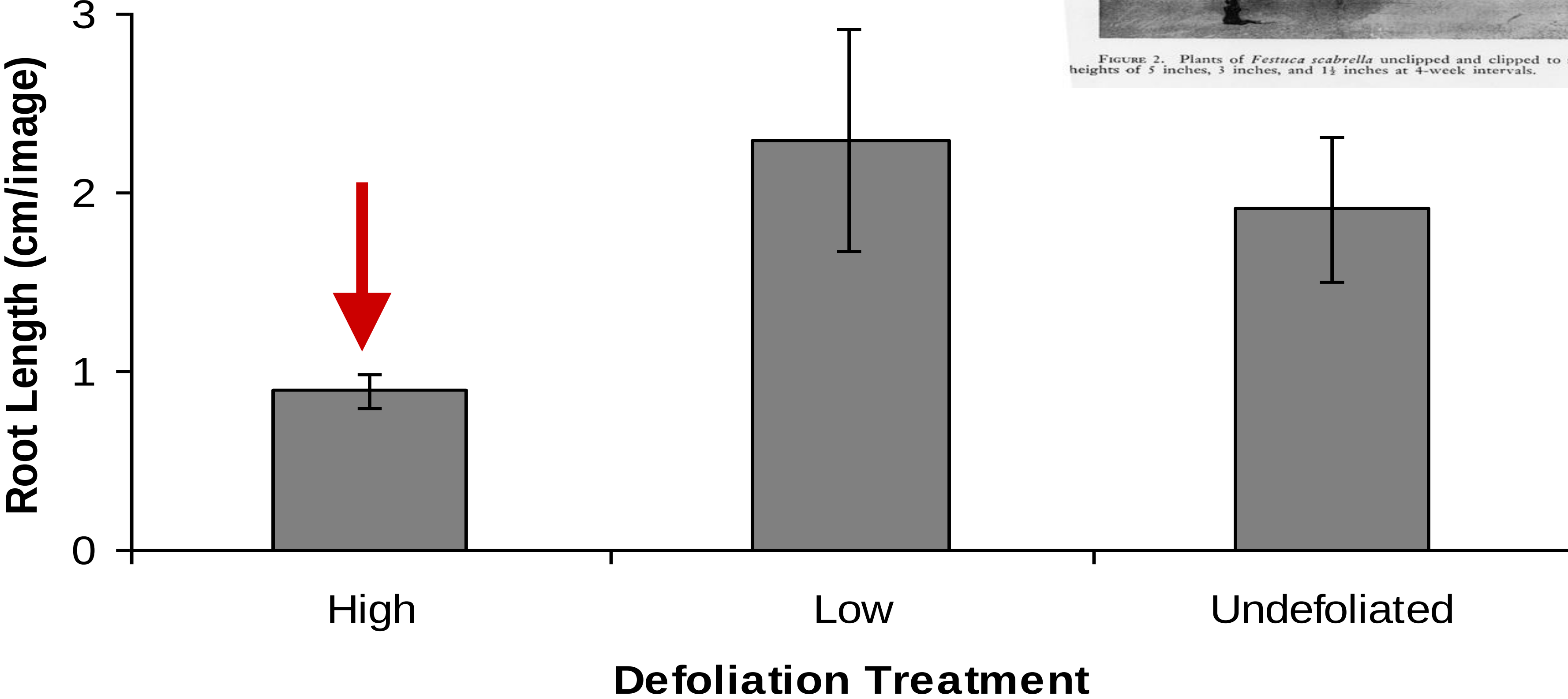
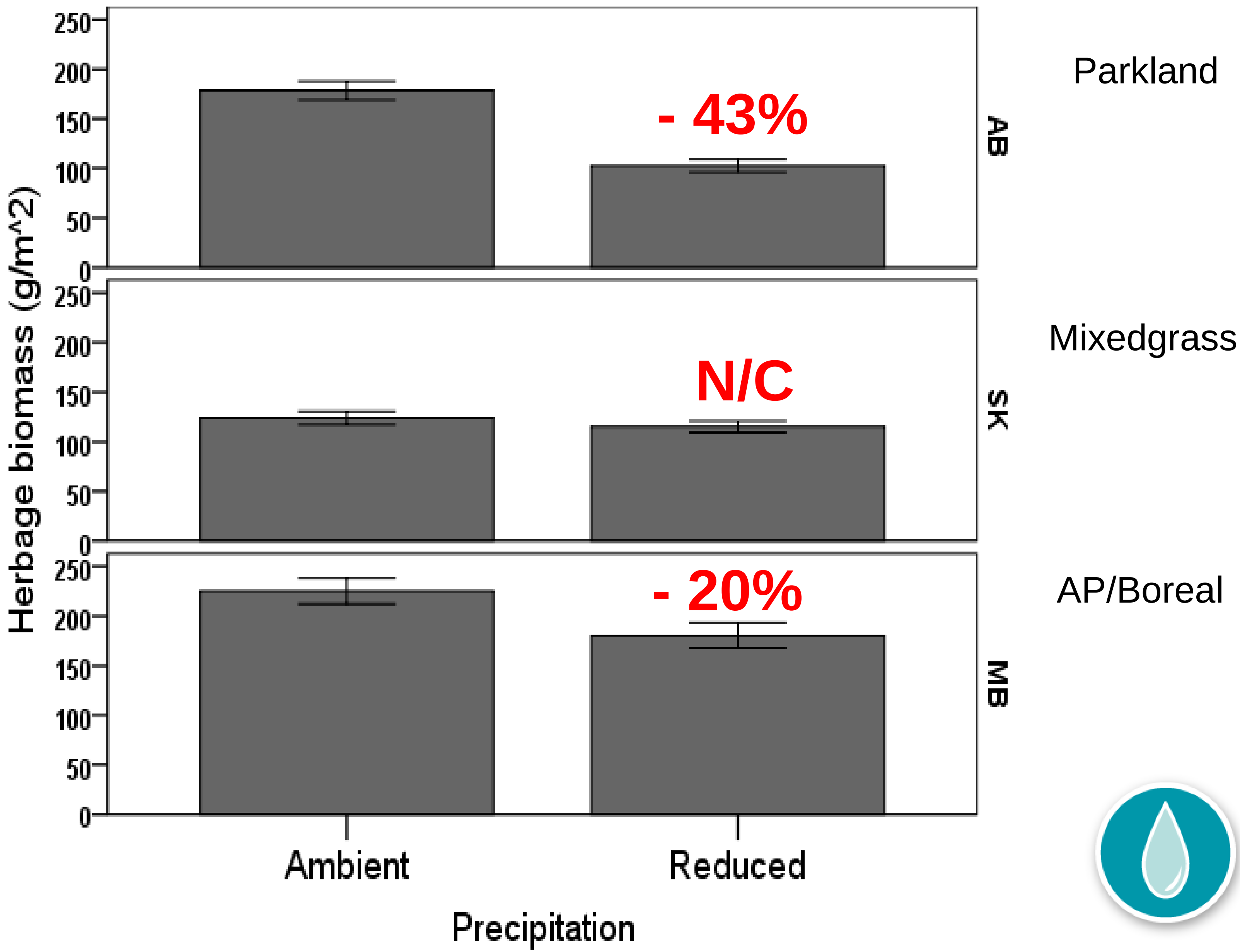


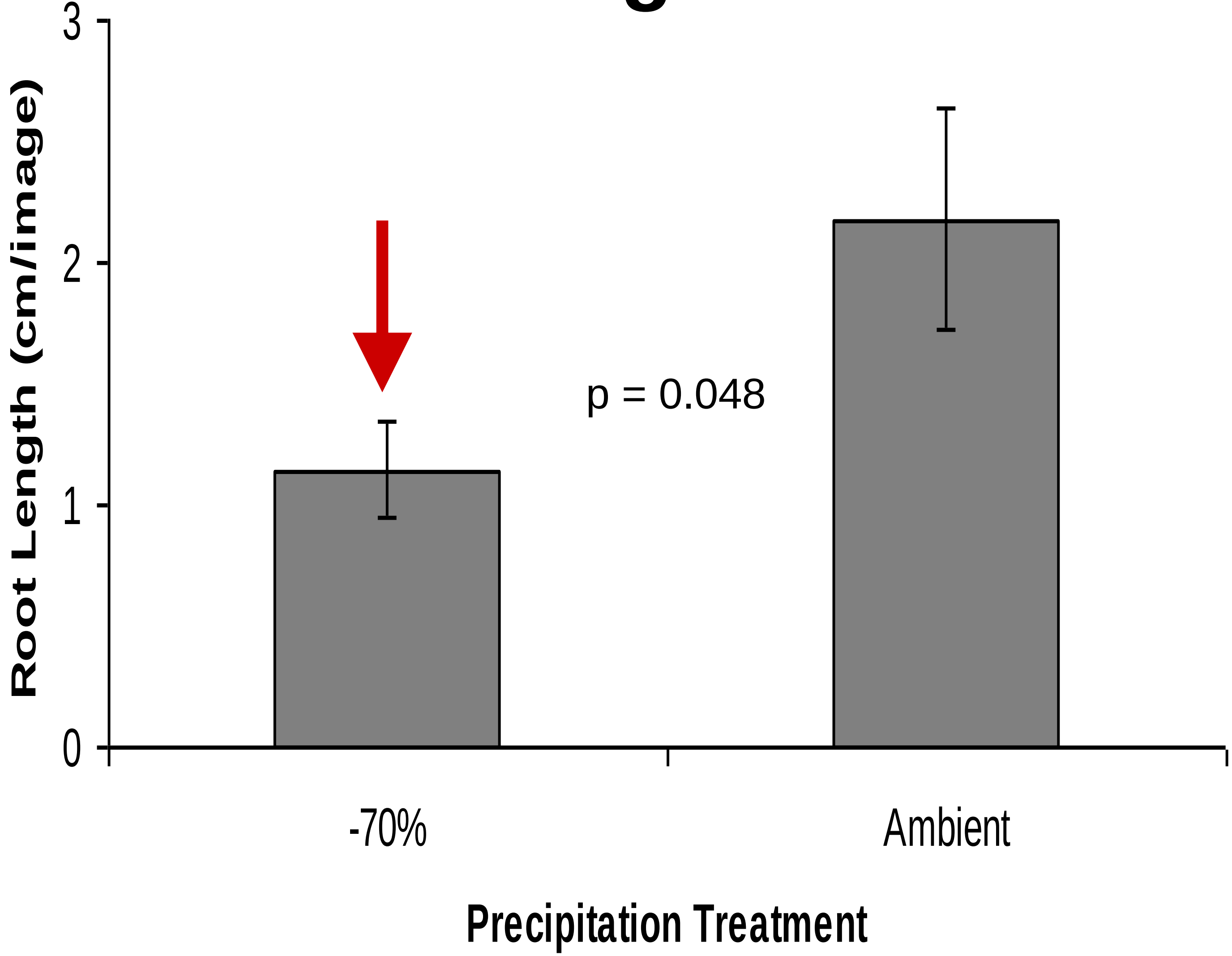
FIGURE 2. Plants of *Festuca scabrella* unclipped and clipped to stubble heights of 5 inches, 3 inches, and 1½ inches at 4-week intervals.



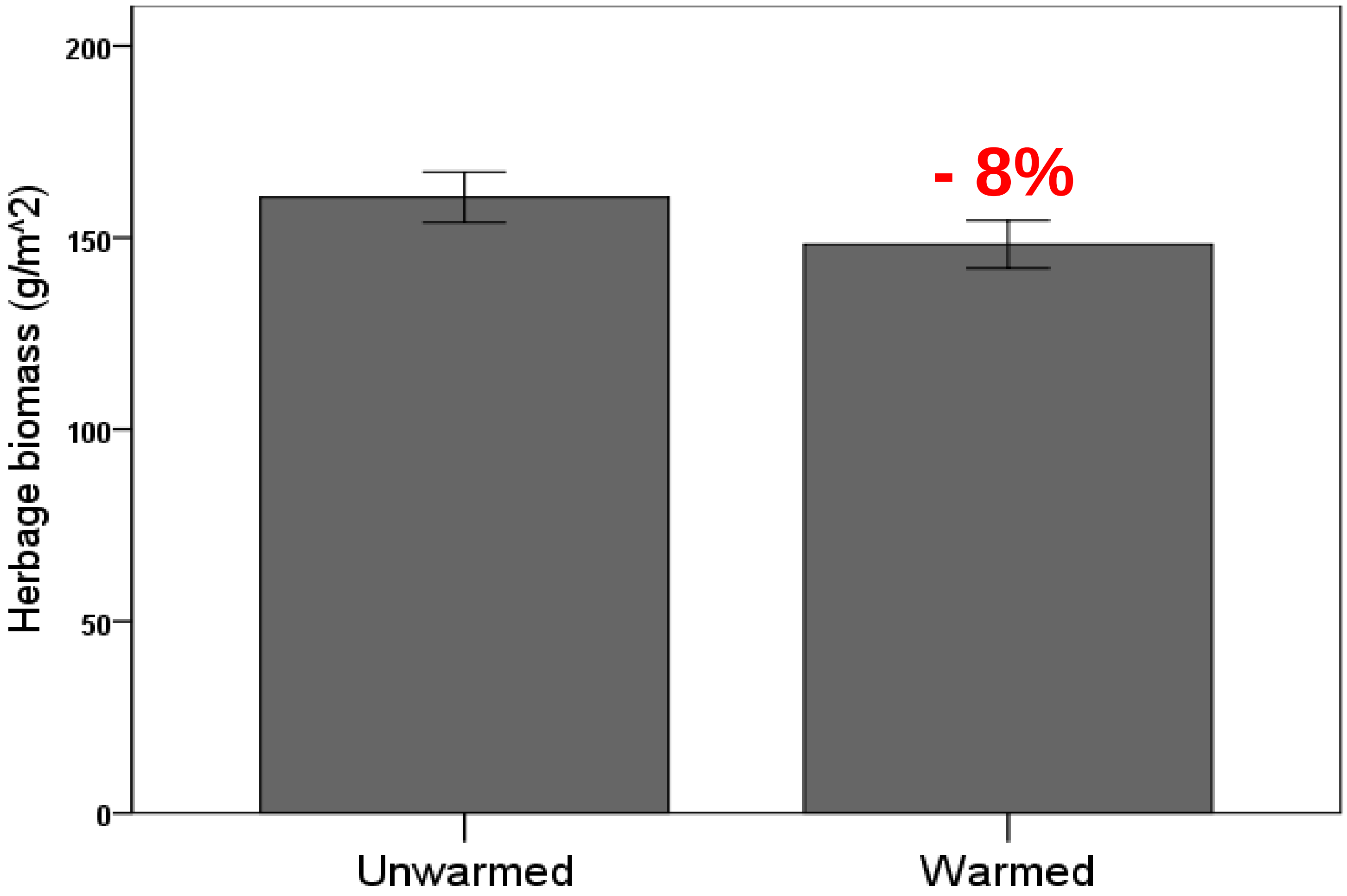
Drought Effects Varied Regionally …



Rooting Length Declined Under Drought

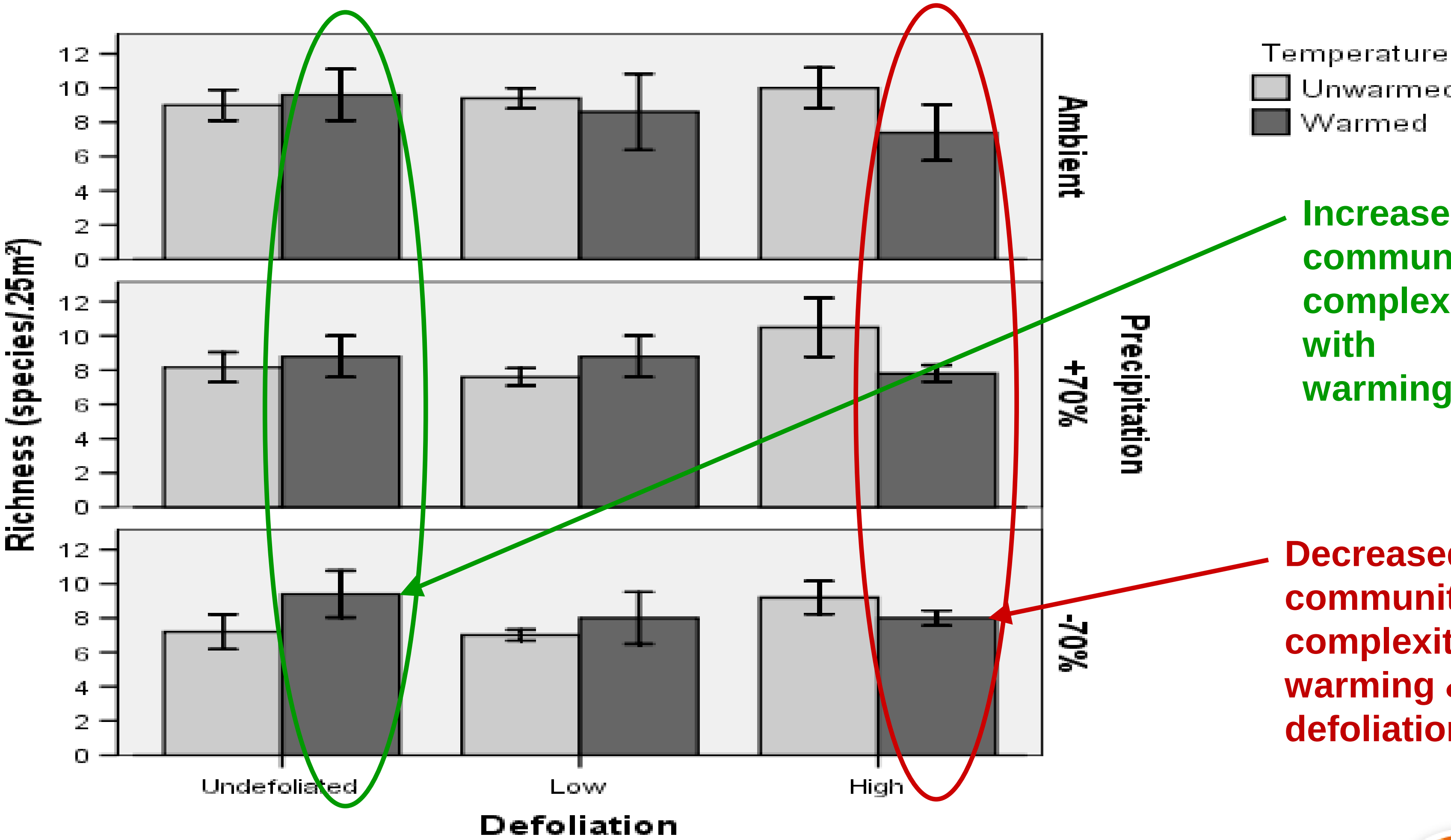


Warming Also Reduced Average Forage Availability



+1.3-2.2 deg C throughout the growing season

Total Plant Species Richness

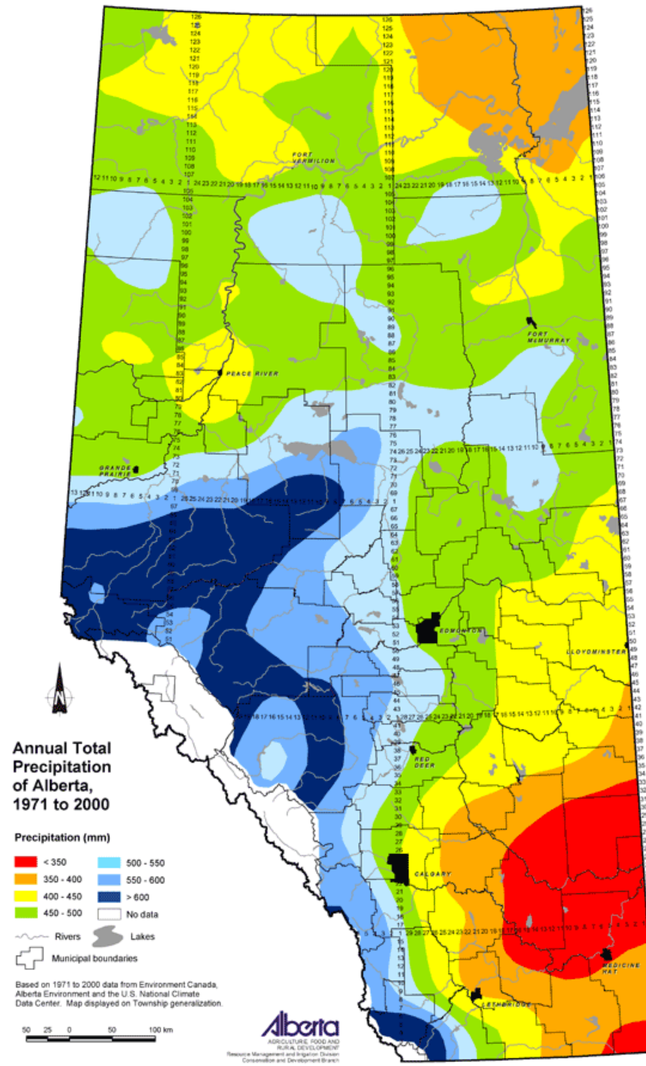


Increased community complexity with warming

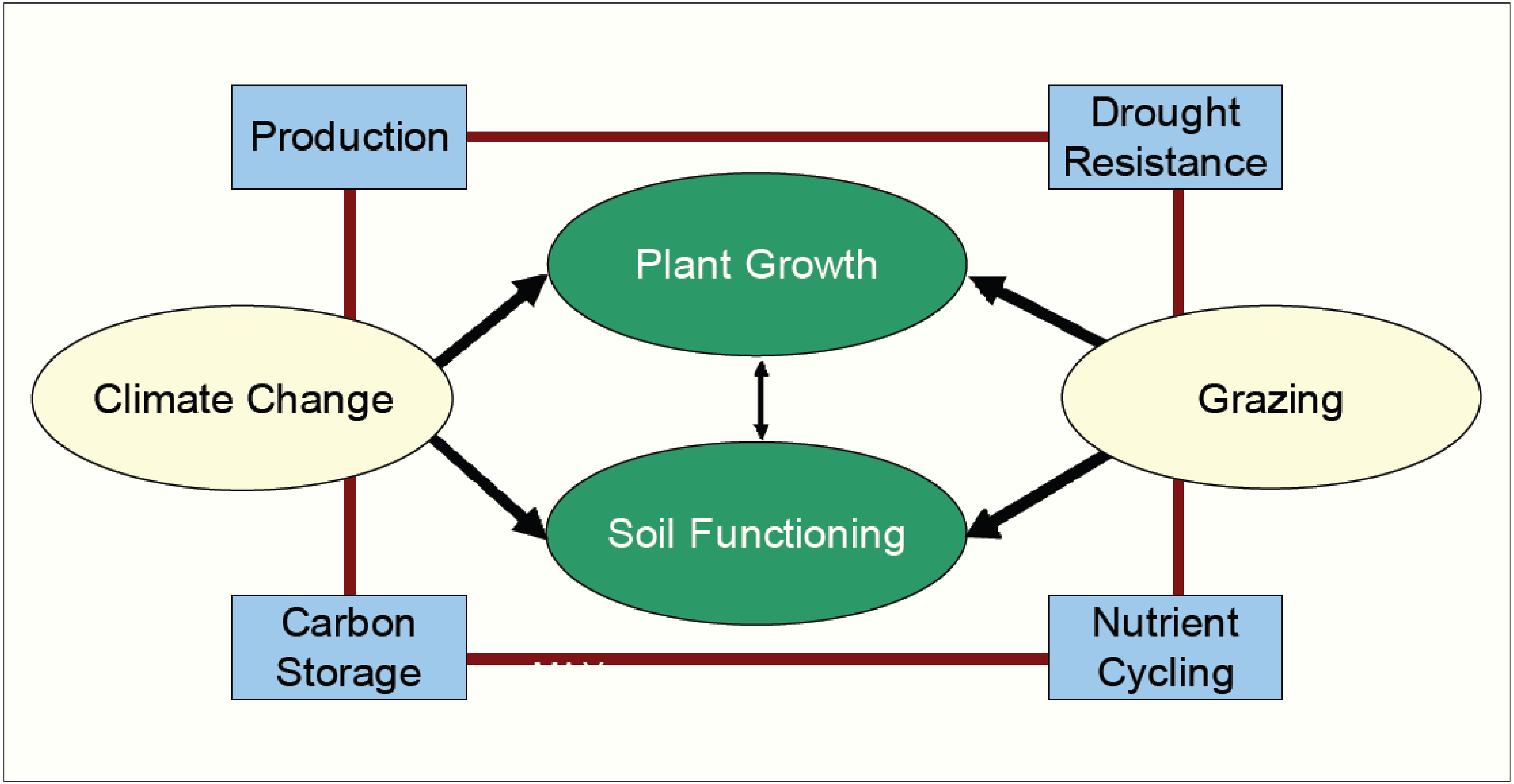
Decreased community complexity with warming & defoliation

New Study (7 regional sites):
Impact of defoliation regimes and drought on EG & S (forage, biodiversity, C and GHG)

- Ideal grazing systems under drought may vary with soil, vegetation, etc.



Social Implications of a Changing Climate …?



Numerous Funders

ALMA
Alberta Livestock
and Meat Agency Ltd.

CCEMC
Climate Change & Emissions
Management Corporation

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