Cultivation and grazing impact on extracellular enzyme activity in alberta grasslands

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INTRODUCTION

Grasslands cover a quarter of the planet's land surface and constitute 70% of the world's agricultural land area. Grasslands provide clean water, facilitate nutrient cycling, and provide habitat and forage for livestock and wildlife.

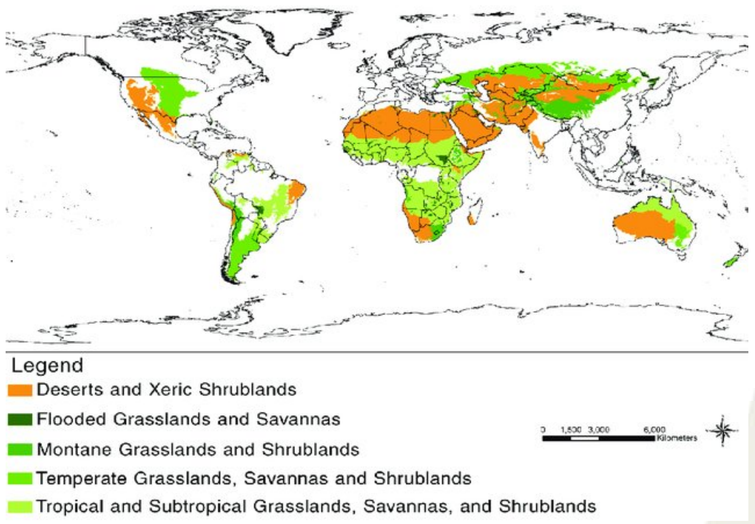

Fig. 1: Map of world grasslands.
Cobon DH, Baethgen WE, Landman W, Williams A, Archer van Garderen E, Johnston P, Malherbe J, Maluleke P, Ben Kgakatsi I, Davis P. Agrodimatology in grasslands. Agrodimatology: Linking Agriculture to Climate. 2017 Mar 1(agronmonogr60).

Grazing is the most common use of grasslands and may alter carbon (C) and nutrient mineralisation. Therefore, understanding the impact of grazing management, as well as past management practices (cultivation), climate, and soil properties are of great interest on C and nutrient cycling. Continuous (CG) and rotational (RG) are common grazing systems. In CG, livestock graze one expansive area for the entire grazing season. In RG, one ranch is divided into smaller paddocks (4-8 paddocks), which in turn facilitates greater control over grazing land. Adaptive multi-paddock grazing (AMP) was included in our study, which is an intensive system with animals stocked at high density and rotated through many paddocks (20-50) in short grazing time. This study examined the role of grazing systems on soil biogeochemical cycling by measuring extracellular enzyme activity (EEA), which is an indicator of soil biological activity.

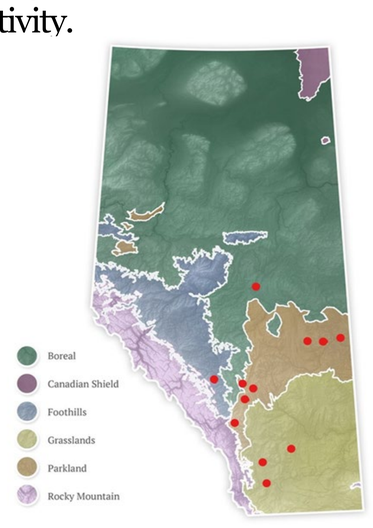

Fig. 2: Alberta ecoregions map from the status of human footprint in Alberta. https://abmica.ca/home/reports/2018/human-footprint/NaturalRegions Red dots represent study sites.

MATERIALS AND METHODS

Study ranches (N = 24) were located in pairs at 12 sites within the Mixedgrass Prairie, Fescue Grasslnads, Aspen Parkland, and Boreal transition subregions of Alberta. Each site include two ranches with one AMP and one conventional (continuous and rotational) (Non-AMP) grazing systems.

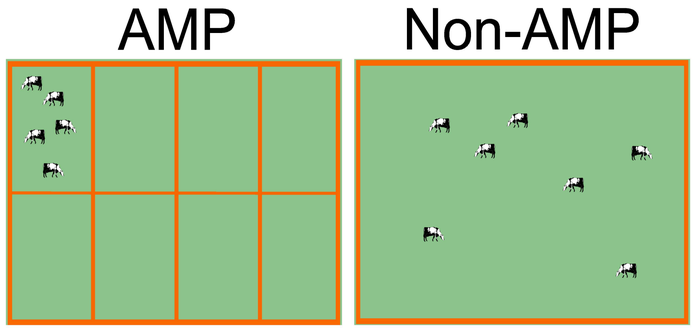

Fig. 3: The model of adaptive multi-paddock grazing (AMP) and continuous grazing (Non-AMP) systems.

Most ranches within a ranch pair had the same cultivation history, with two exceptions. Within a pair, ranches were located relatively close to each other (< 5 km) and had similar soil properties (texture, pH), topography, and elevation. A detailed survey of each ranch operator was conducted to obtain the information on management practices.

Table 1: The list of extracellular enzymes studied in this experiment and the end products of their reactions.

Enzyme	Product of Reaction
Cellobiosidase	Disaccharides (cellobiose)
β-glucosidase	Monosaccharides (glucose)
Xylosidase	xylose
N-acetyl-β-glucosaminidase	N-acetylglucosamine
Urease	ammonia and CO_2
Phosphatase	Phosphate ion

An AIC ranking approach was used to compare models for their ability to explain each EEA (Anderson et al., 2000).

Table 2: Baseline regression models examined in the initial analysis, split into the sub-groups of management factors, macro- and microdimate, and local soil properties, for the EEA associated with soil (0-15 cm layer) removed from individual ranches.

Sub-groups	Regression models
Management	Cultivated
	Stocking rate (SR)
	Rest:graze ratio (RGR)
	Cultivated + SR
	Cultivated + RGR
	Cultivated + SR + RGR + (SR * RGR)
Climate	Annual heat moisture index (AHM)
	Soil moisture
	AHM + Soil moisture
Soil Properties	Sand:Clay
	Soil pH
	Available nitrogen (AN)
	Microbial biomass carbon (MBC)
	Sand:Clay + Soil pH
	Sand:Clay + Soil pH + AN
	Sand:Clay + Soil pH + AN + MBC

MAIN RESULTS

Results showed that a lengthy rest to grazing period ratio (mainly present in AMP ranches) increased β-glucosidase activity, while high cattle stocking increased urease activity. In contrast, soils previously cultivated had lower xylosidase and phosphatase activities, suggesting a legacy effect of past cultivation. The main factors regulating enzyme activities were available soil N and climatic aridity. Overall, grazing and cultivation history appear to be capable of altering C and nutrient cycling in these temperate grasslands. This study highlights the importance of grassland management in influencing biological activity.

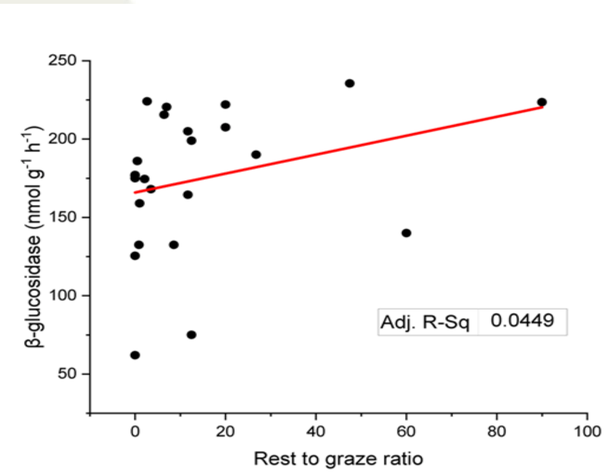

Fig. 4: The relationship between β-glucosidase activity (nmol g^{-1} h^{-1}) and ratio of rest to grazing days during the early growing season, P=0.16.

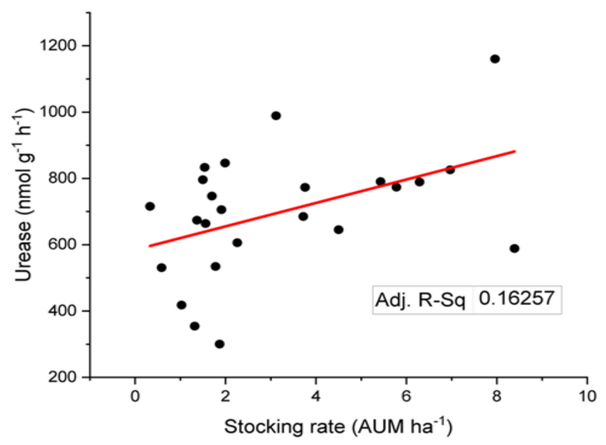

Fig. 5: The relationship between urease activity (nmol g^{-1} h^{-1}) and stocking rate (animal unit month ha $^{-1}$), P=0.02.

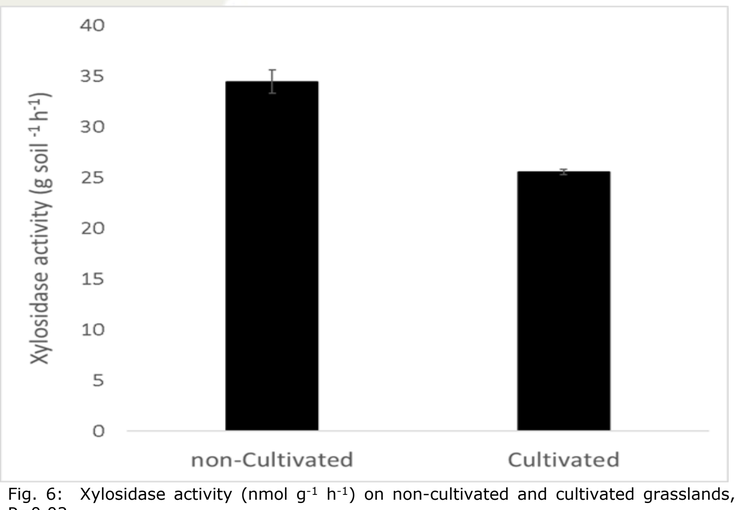

Fig. 6: Xylosidase activity (nmol g^{-1} h^{-1}) on non-cultivated and cultivated grasslands, P=0.02.

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