Grazing Mediated Impacts on Litter Decomposition May Help Alberta Grasslands be Managed to Mitigate Climate Change

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Foothills study site. Photo from Sean Chuan.

Rising atmospheric CO_2 levels have created an unprecedented interest in developing mitigation strategies to increase carbon (C) storage and reduce agricultural greenhouse gases (GHGs). Grasslands are one of the most widely distributed biomes globally, and are known to store nearly three times the C found in the atmosphere, while also supporting rural communities. Current market uses for rangelands in Canada are limited to forage and livestock production, while many of the secondary ecological goods and services (water storage, provision of biodiversity, consumptive wildlife, recreational pursuits and C storage) that they provide are undervalued in our economy.

While the role of intact native grasslands in provisioning C storage is well known, less is understood about how ongoing grazing alters C stores, including the mechanism by which this is likely to occur. One such mechanism is the rate of plant litter decomposition, as this provides a transformation pathway for C into soil organic matter. Moreover, grazing is known to alter plant community composition, and differences in plant chemistry induced by decades of use may therefore alter decomposition rates.

In 2014, Dr. Daniel Hewins (now an Assistant Professor of Biology at Rhode Island College), then post-doctoral fellow at the University of Alberta, helped initiate a study evaluating rates of litter mass loss from May 2014 through October 2016 at 15 locations distributed across three agro-climatic zones of south-central Alberta. Testing was further stratified into grazed and non-grazed areas, with a total of 7 different dominant grass species evaluated. Sean Chuan (MSc. 2017) was added to the project in 2014 to measure the activities of 5 important extracellular enzyme activities (EEA) responsible for C, nitrogen (N) and phosphorus (P) cycling in litter and soil samples.

Findings indicate that rates of litter mass loss were greater in high rainfall Foothills Fescue grasslands of SW Alberta compared to more arid grasslands of the Mixedgrass Prairie. Additionally, litter situated in grazed environments tended to decay faster than the same litter situated in their non-grazed counterparts, particularly in mesic to high rainfall areas, and coincided with increases in the enzymes responsible for C-liberation. In contrast, litter in non-grazed areas had greater levels of the EEAs responsible for nutrient (N and P) cycling, presumably due to the lack of direct effects of animals on vegetation breakdown. Marked differences in decomposition rates were also evident among many of the plant species tested, with Kentucky bluegrass, a common but productive introduced forage grass in the Fescue Grasslands of SW Alberta, decaying faster than other species at that location. Given that bluegrass is a well-known increaser under grazing, faster decomposition of this species may provide novel insight into how grazing-induced shifts towards this species are altering biogeochemical cycling, and potentially C storage. In the Mixedgrass Prairie, blue grama, a warm-season grass that normally is relatively resistant to decay, unexpectedly had the highest EEA. The widespread native species western wheatgrass had among the slowest decomposition rates.

Sampling litter bags. Photo from Sean Chuan.

Overall, these results highlight 1) that strong variation exists regionally in grass decomposition rates, and that these vary further with ongoing exposure to grazing and the identity of grass species, and 2) that the use of EEAs provided new insight into where, why, and how the decomposition of vegetation varies across these grasslands. When coupled with information on soil C storage, GHG emissions, and perhaps C labeling studies in the future, these data should provide significant insight into the development of beneficial management practices under grazing that can optimize C storage and reduce the agricultural GHG footprint.

This research has been published:

Chuan, X.Z., Carlyle, C.N., Bork, E.W., Chang, S.X., Hewins, D.B. 2018. Long-Term Grazing Accelerated Litter Decomposition in Northern Temperate Grasslands. Ecosystems 21(7): 1321-1334.

Hewins, D.B., Chuan, X.Z., Bork, E.W., Carlyle, C.N., 2016. Measuring the effect of freezing on hydrolytic and oxidative extracellular enzyme activities associated with plant litter decomposition. Pedobiologia 59(5-6): 253-256.