UNIVERSITY OF ALBERTA

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Understanding the effect of defoliation intensity on carbon flow at two ecosites at the Mattheis Ranch

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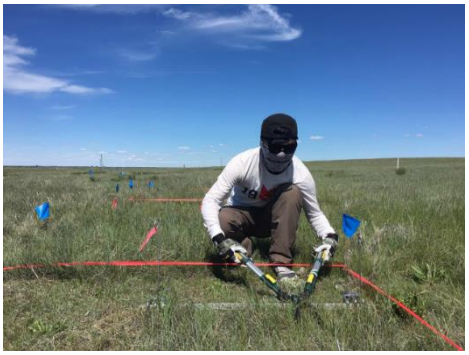
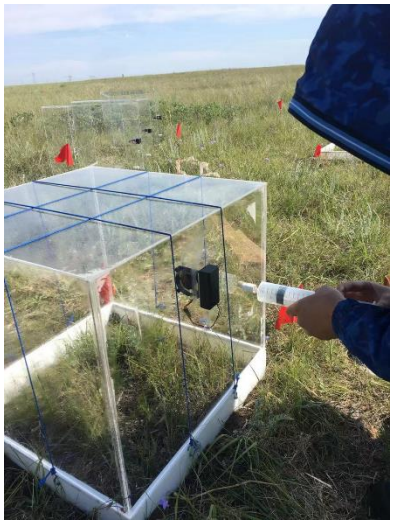
Livestock grazing is an important driver of the carbon (C) cycle in grasslands and can strongly affect the C source-sink relationship in the ecosystem, with implications for both the sustainability of managed grasslands and for the potential contribution of grasslands to climate change mitigation. One of the aspects that will affect C cycling in grasslands is grazing intensity. High-intensity grazing removes much of the leaf area of grassland plants, reducing the potential flow of C belowground to build the root system, as the amount of C fixed by photosynthesis is reduced, which may therefore adversely affect the sustainability of the ecosystem. The response of grasslands to grazing intensity in terms of the allocation of photosynthates in the plant-soil system would be affected by the ecological condition (e.g., water availability as affected by the soil texture) of the site.



Post-doctoral fellow, Dr. Zilong Ma, applies the defoliation intensity treatments to research plots at the Mattheis Ranch, as a way of simulating cattle grazing.



Chambers built for applying the ^{13}C-enriched CO_2. As are shown here, ^{13}C-enriched CO_2 had been injected into the chambers and plants inside the chambers were taken up CO_2 with a different ^{13}C abundance from the ambient atmosphere.

To improve our understanding of the effect of defoliation intensity and ecosite type on carbon flow, we tested the hypotheses that 1) photosynthetic C allocation in the plant-soil system of grasslands is differentially affected by grazing intensity the prior growing season and 2) the C allocation would also be affected by the ecosite type. We studied the fate of new C assimilates, using a $^{13}CO_2$ pulse-labelling technique, as

they move from shoots to roots and soil in vegetation previously exposed to different defoliation (emulating grazing) intensities in two semiarid Mixed Prairie grassland ecosites having contrasting soil textures (sandy vs. loamy) at the Mattheis Ranch.

Our research found that within 24 h after photosynthetic uptake of the $^{13}CO_2$, on average, 34.5% of the labelled C was translocated out of shoots, with 21% of the labelled C found in the mineral soil. Plant communities treated with high-intensity defoliation during the previous growing season had more of the newly fixed ^{13}C translocate into live roots at both ecosites throughout the chase period (between the ^{13}C labelling and the time of destructive sampling of the labelled plant community), indicating a higher demand for photosynthetic C by the root system of heavily defoliated plants. Twenty-five days after labelling, ^{13}C transfer into the top 30 cm mineral soil was consistently greater at the loamy (26% of total ^{13}C remaining) than at the sandy ecosite (10.4% of ^{13}C remaining) (Fig. 1). Our results thus supported both of the hypotheses about the impact of grazing intensity and ecosite type on C allocation in the plant-soil system.

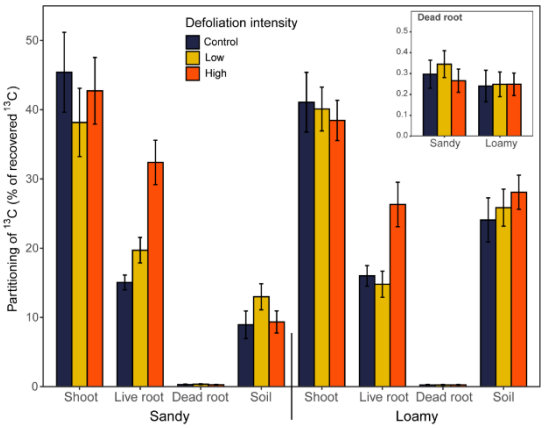


Fig. 1. Partitioning of 13C (percentage of 13C recovered) in plant shoots, roots (both live and dead), as well as mineral soil under previous exposure to different defoliation treatments and within different ecosites at the end (day 25) of the chase period. Results for roots and soil are shown for the combined sampling layers (0-30 cm). Error bars indicate ± SE (n = 4).

We conclude that conditioning with high-intensity defoliation the prior growing season stimulated short-term C allocation to roots in these semiarid grasslands. Although this response was independent of soil texture, more C was translocated belowground overall in the loamy ecosite. The effect of defoliation intensity and ecosite in regulating short-term C allocation in the plant-soil system in temperate grasslands should be incorporated into future models describing C cycling in grasslands when predicting C dynamics under different management strategies employing contrasting grazing intensities.

A portion of this work is published: Ma, Z., E.W. Bork, J. Li, G. Chen, and S.X. Chang. 2021. Photosynthetic carbon allocation to live roots increases the year following high intensity defoliation across two ecosites in a temperate mixed grassland. Agriculture, Ecosystems and Environment, 316: 107450. DOI: 10.1016/j.agee.2021.107450