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Interactions between defoliation, warming, and drought in a native northern grassland in Alberta, Canada

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Introduction Canada contains 22 M ha of land dedicated to range and forage production, where the majority of C is produced and stored belowground (Steinaker and Wilson 2005). A healthy rangeland stores equivalent C mass per ha as forested ecosystems, and because this C is primarily belowground, it is at lower risk of release during fires. Consequently, healthy grassland ecosystems may play a significant role in mitigating global climate change. Overgrazing has been documented on up to half of all rangelands in the region, and through a potential decline in root biomass, may reduce soil carbon storage. Coupled with predictions of climate change, these disturbances are likely to further change range health. Improvement of rangeland condition provides direct economic benefits, and because native rangelands store more C than annual croplands, this should also lead to increased C storage, with implications for feedback to climate systems both locally and globally. We however have a relatively poor understanding of how range management practices such as grazing intensity and the predicted future climate (which may become warmer and drier in some regions) interact to affect the function of the native northern temperate grassland ecosystems (Zhou et al. 2006).

Materials and methods We used a randomized complete block design with 5 blocks for a 2 (warming vs. non-warming) x 3 (two intensities of clipping to simulate grazing vs. no clipping) × 2 (drought vs no drought) factorial experiment for the full study which began in spring 2007. The warming treatment was applied using open-top chambers (OTC, 40 cm high and 2 m in diameter) that can increase the near surface air temperature by 2-4℃. As the size of OTCs precluded the use of actual ungulate grazing, simulated grazing was achieved through manual clipping of vegetation in and around (buffer) each plot. Simulated grazing of low and high intensity treatments consisted of clipping to a stubble height of approximately 7.5 m and 2.5 cm, which roughly corresponded to the removal of 30% and 80% of standing current annual biomass. Drought treatments were applied using shelters that intercepted 70% of natural precipitation. In each plot, near surface air temperature, soil temperature and soil moisture content were measured continuously, plant community compositional responses were assessed at peak biomass, soil N availabilities were measured using the Plant Root Simulators (PRS) probes, and fluxes of CO_2 and N_2O were determined using a static gas chamber-gas chromatograph system. Rates of N mineralization were determined using the buried-bag method. Microbial biomass C and N were measured using the fumigation-extraction method. Soil microbial functional diversity and composition were studied using the Biolog and phospholipid fatty acid (PLFA) techniques. A mini-rhizotron was used to estimate belowground primary productivity and carbon flow.

Results Preliminary results from a pilot study conducted in 2006-07 showed that the combined warming by defoliation treatment produced an additional increase in soil (0-5 cm) temperature of about 2 °C relative to all other treatments during August 2006. Soil moisture content exhibited high temporal variability throughout the growing season of 2006 likely reflecting fluctuations in rainfall during this period. Plant community species richness and diversity remained relatively stable throughout the growing season in 2006 and differences among the treatments were relatively minor. Due to warming, rough fescue (*Festuca hallii*) increased in canopy cover, but towards the end of the growing season had fewer tillers. Warming also altered the morphology of many-flowered aster (*Aster falcatus*) and bastard toadflax (*Commandra umbellata*). Few treatment effects were observed for soil microbial biomass C and N, but both parameters had large seasonal variations. In June 2006, the warming treatment resulted in greater ammonification, and defoliation decreased the net nitrification rates, both in the 0-5 cm soil layer. Nitrification was the dominant process in the transformation of organic N to inorganic form in the system. We have so far observed few other significant differences caused by the treatments.

Conclusions These northern temperate fescue grasslands appear rather resilient to changes in the climatic conditions and management practices in the first year of a pilot study. However, we predict that over the longer-term (e.g., up to three years), the grassland ecosystem under study will respond to sustained changes in climate and management treatments in a much more significant way, as changes in plant growth will have cascading effects on ecosystem processes.

References

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