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Multi-species grazing, mob grazing, and fire effects on cool-season grass invaded rangelands of the northern great plains of north America

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Keywords
Livestock management, prescribed fire, Long term, alternative management, invasive species

Abstract
Grasslands in the northern Great Plains of North America sustain abundant plants, wildlife, and livestock but are threatened by invasive plant species. Predicted shifts toward more variable weather will challenge sustainable management of these grasslands. Effective and feasible management options need to be developed in collaboration with, and for, land managers. As part of the Long-Term Agroecosystem Research (LTAR) network, a nationwide network with 19 research sites focused on developing strategies to address current agricultural needs, we initiated an experiment in 2019 to answer whether applying fire and/or grazing can reduce the dominance of invasive Kentucky bluegrass (*Poa pratensis*) in North America's northern Great Plains ecosystems. We contrast a prevailing practice (season-long grazing at a moderate stocking rate) with four alternative practices at a half-hectare plot scale: (1) mob grazing (high intensity, short duration) by cattle, (2) multi-species grazing (mob grazing by cattle, with goats foraging at key times of the year), (3) prescribed fire, and (4) prescribed fire followed by cattle grazing. A stakeholder group was engaged in making decisions to determine alternative practices and how to apply them. Every five years, the treatment with the best overall outcomes is applied at a field scale (15 ha). We found that prescribed fire and mob grazing reduced the cover of Kentucky bluegrass and increased the cover of some native plant species. When combined, prescribed fire and grazing had the most reductions in Kentucky bluegrass and increases in native plant species. However, there are trade-offs associated with each treatment related to plant production and nutritive values, livestock weight gain, and soil compaction and infiltration. We discuss results in the context of optimizing land management based on land manager goals and current and future economic and ecosystem benefits.

Introduction

Naturally occurring fire, indigenous fire management, grazing, and soils shaped the vegetative communities on the Great Plains (Epstein et al. 1997, Fuhlendorf and Engle 2001, Lake and Christianson 2020). However, since European settlement, fire and grazing regimes on the Great Plains have been severely altered. These changes have resulted in increased abundance of invasive perennial cool-season grasses severely altering the species composition in the primarily cool-season dominated plant communities in the northern Great Plains.

Fire suppression in fire-adapted rangelands generally results in cascading ecosystem changes that not only affect the local area in which fires occur but influences the delivery of ecosystem services at landscape and watershed scales. From an ecological perspective, suppressing fire in fire-adapted ecosystems inhibits natural regulating processes and, consequently, promotes ecosystem degradation (Backer et al. 2004). From an economic perspective, ecosystem changes associated with fire suppression have led to reduced grazing land resilience, lower land productivity, changes in livestock carrying capacity, and increased risk of loss of property and life to catastrophic fires resulting from fuel load accumulation (Pyne 1984; Teague et al. 2001, Toledo et al. 2014).

Mob grazing is increasingly popular with producers, but the impacts of the practice, especially on soil and vegetative composition, are unclear. This is also true of other alternative animal practices such as multi-species grazing (Walker 1997). There is a need to evaluate and compare the impacts of alternative grazing management practices and prescribed burning on vegetation and soils.

Methods

The experiment was located on native rangeland at the Northern Great Plains Research Laboratory, USDA-ARS, which has been invaded by the perennial cool-season grass, Kentucky bluegrass. Five different land management treatments were replicated four times each in a randomized complete block design. The five treatments were (1) grazing with cattle only at a moderate stocking rate until 50% of the palatable vegetation was removed (Control); (2) use of a mob grazing technique (high intensity, short duration) for cattle only (MOBC), (3) grazing by goats and mob grazing by cattle (MOBCSR); (4) a fall prescribed fire(Fire); and (5) a fall prescribed fire that was grazed by cattle in the following spring (FireC). Each treatment was randomly assigned to a 0.5 ha plot within each block. We implemented a staggered start design, meaning that 2 experimental blocks were started in 2019, and the remaining 2 experimental blocks were started in 2020. To minimize the impact of plot size, treatment blocks were selected with care to represent the landscape and reduce potential sources of variability. Treatments were located on Loamy Ecological Sites (USDA 2024).

Vegetation sampling on each plot was conducted using the Modified Whittaker technique (Stohlgren et al. 1995; Stohlgren 2007) and the line intercept method (Herrick et al. 2005). Rangeland health assessments were performed using the Integrated Grazingland Health Assessment protocol (Toledo et al. 2016).

Soil attributes were measured in all treatments prior to treatment deployment, throughout the study, and at the end of the study. Samples were collected from depth increments of 0-0.05, 0.05-0.1, 0.1-0.2, 0.2-0.3, and 0.3-0.6 m using a hydraulic sampler and analyzed for physical, chemical, and biological attributes. Attributes included soil bulk density, water-stable aggregation (physical), soil pH, electrical conductivity, exchangeable cations, available N and P, micronutrients, total C and N, and particulate organic matter C and N, (chemical), and C mineralization, potentially mineralizable N, and phospholipid fatty acid profiles (biological). Field measurements of sorptivity, penetration resistance, and soil water content were

conducted annually before and after grazing, while saturated hydraulic conductivity was measured after grazing.

Results

We found that prescribed fire and mob grazing reduced the cover of the invasive Kentucky bluegrass (Figure 1). When combined, prescribed fire and grazing had the most reductions in bluegrass. However, there were trade-offs associated with each treatment related to plant cover and livestock weight gain.

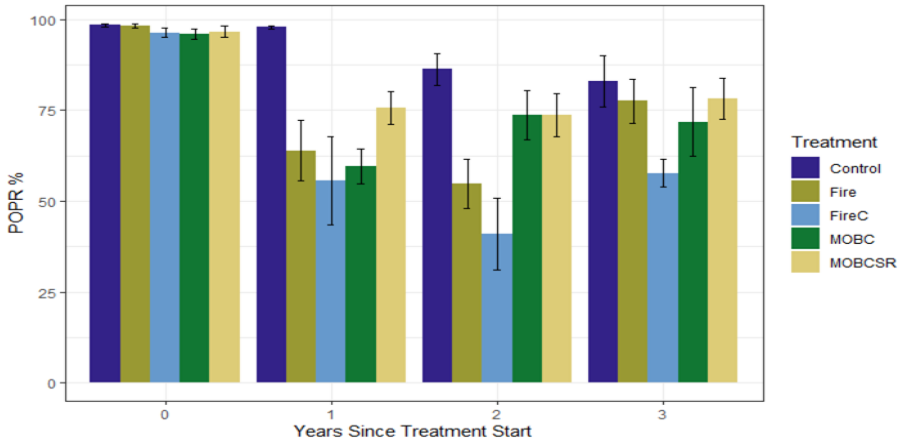

Figure 1. Percentage cover of Kentucky bluegrass (*Poa pratensis*; POPR) in treatment plots before the start of treatments and each year since treatment started. Error bars were constructed using one standard error from the mean.

Livestock weight gain differences between the control and mob grazing treatments were not significantly different in 2021 or 2023 and were only significantly different in 2022. However, there was a trend of slightly higher weight gains per hectare in the mob treatments (Figure 2). Qualitative rangeland health data (visible platy structure near the soil surface) suggest plots that were mob grazed were more compacted than plots that were grazed season-long, and the ease with which pores of a saturated soil-transmitted water was greater in the control and fire treatments than in the mob treatments but results vary by year (Figure 3).

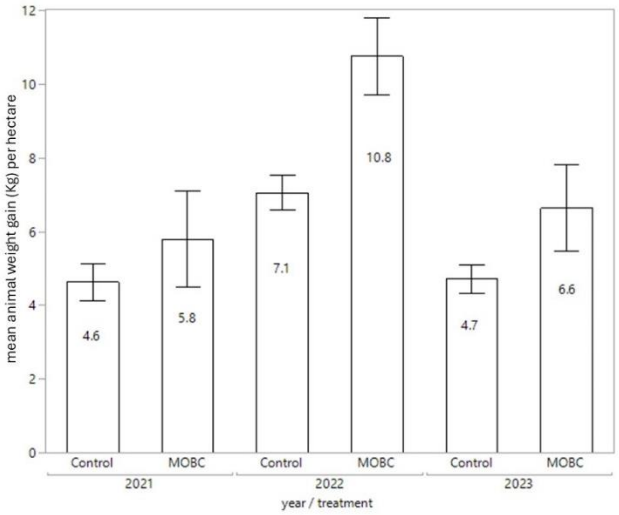

Figure 2. Twenty-eight-day mean animal weight gain (Kg) per hectare on season-long grazing (Control) and mob grazing (MOBC, alternative practice) by year. Error bar constructed using one standard error from the mean. Livestock did not graze fire treatments long enough to produce reliable weight data.

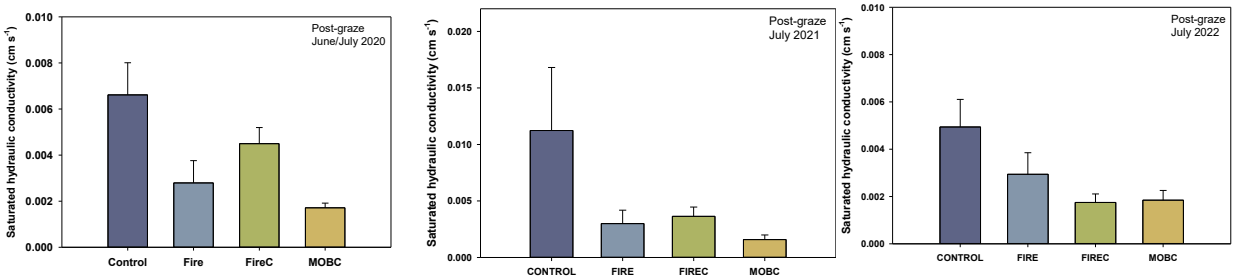

Figure 3. 2020, 2021, and 2022 post-graze saturated hydraulic conductivity of season-long grazing control (prevailing practice), fire treatment (Fire), fire treatment that was grazed by cattle (FireC), and mob grazing treatment (MOBC).

Discussion [Conclusions/Implications]

Fire treatments were more effective at reducing cover of Kentucky bluegrass than the other treatments. Mob grazing showed reductions in bluegrass and increases in weight gain per hectare compared to the control, but results were not consistently significant and were also associated with negative changes in soil physical condition. We were unable to compare weight gains of livestock in grazed fire treatments because they spent too little time on the treatments to produce reliable weight data.

Although Kentucky bluegrass is a palatable and productive grass (Toledo et al. 2014), no treatment is not an option if the goal is to maintain healthy and productive rangelands in the northern Great Plains. The combination of fire and grazing provided the most positive results in terms of Kentucky bluegrass reductions. In a region where prescribed fire is not always seen as positive, it was important for landowners who were part of the stakeholder group to see these results first-hand. Land managers need to evaluate their goals for their land and the current and future economic and ecosystem benefits and constraints of applying any of these treatments.

Acknowledgements
We acknowledge the contributions of our project-specific customer focus group, the many landowners and agency personnel who have contributed comments and ideas throughout the experiment, and Chris Gordon at The Nature Conservancy Cross Ranch Preserve for prescribed fire training and help during burning days. We would also like to acknowledge the contributions of the small army of technicians who keep this experiment running and ensure that all measurements are taken precisely and consistently. A special thanks to Daniel Asplin, Justin Feld, Shawn Miller, Michael DeGreef, Clay Erickson, Rebecca Knutson, Nicole Davidson, Allison Bargmann, Jenny Hanson, Raina Hanley, and Olivia Avery for their help with running this experiment and data collection. This publication is a contribution from the Long-Term Agroecosystem Research (LTAR) network. LTAR is supported by USDA. This work is also being supported by funds from a Conservation Effects Assessment Project jointly funded by the USDA NRCS and USDA ARS.

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