Impacts of Patch-burn, Rotational and Continuous Grazing on Livestock Performance and Conception Rates on Kentucky Bluegrass-invaded Mixed-grass Prairie

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Introduction

Controlled livestock distribution and reduced grazing intensity can be implemented to enhance wildlife habitat and promote conservation of certain landscapes and some wildlife species. However, traditional approaches to rangeland management to enhance conservation are generally thought to reduce profits from livestock grazing enterprises because traditional approaches reduce the number of grazing animals (Dunn et al., 2010).

Current rangeland management decouples fire from grazing. Further, the decoupling decreases feedbacks created through disturbances leading to homogeneity in rangeland ecosystems. When these disturbances are suppressed, restricted vegetation succession creates stagnant and homogeneous landscapes.

Homogeneity reduces the number of structural and compositional habitats needed to sustain plant and animal populations, resulting in loss of biological diversity. Therefore, conservation-based livestock grazing practices that are profitable and promote biodiversity are clearly needed (O'Connor et al., 2010).

Combining the spatial and temporal interaction of fire and grazing (pyric-herbivory) is a conservation-based approach to management that increases rangeland biodiversity trophic levels and taxonomic orders by creating heterogeneous vegetation structure and composition (Fuhlendorf et al., 2006; Churchwell et al., 2008; Coppedge et al., 2008; Engle et al., 2008; Fuhlendorf et al., 2010). Discrete fires shifting in time across a landscape concentrate grazing while leaving unburned portions of the landscape largely undisturbed.

The undisturbed areas have relatively tall and dense vegetation. Focal grazing on the recently burned areas maintains relatively short vegetation, and transition areas recovering from focal disturbance support diverse vegetation. The three different patch types create a structurally and compositionally heterogeneous landscape (Fuhlendorf and Engle, 2001 and 2004).

Conservation-based livestock grazing and restoration practices that are profitable, reduce exotic plant species and promote biodiversity are clearly needed (O'Connor et al., 2010). Therefore, this project will focus on 1) developing methods to reduce exotic grass species, restore native species on northern Great Plains rangelands, and 2) determine the effect of heterogeneity-based management on livestock production.

Methods: General Design

This study started in 2017 and was conducted at the North Dakota State University Central Grasslands Research Extension Center (CGREC) in south-central North Dakota (lat 46°46'N, long 99°28'W). As part of the North Dakota State Agriculture Experiment Station, the CGREC's mission is to extend scientific research and Extension programming to the surrounding rural communities. It consists of 2,160 hectares (ha) of native grassland and annual crops.

The study area is representative of much of the Great Plains ecoregion, with large tracts of native grassland used for livestock production intermixed with annual small grain and row-crop agriculture. The CGREC is situated in the Missouri Coteau ecoregion of the northern Great Plains, which occupies 125 million hectares, of which approximately 40% is perennial rangeland grazed by livestock.

Irregular, rolling, rocky plains and depressional wetlands characterize the Missouri Coteau ecoregion. The climate is characterized as temperate and experiences an average yearly rainfall of 40.3 centimeters (cm) (Limb et al., 2018).

Vegetation at the CGREC has been sampled recently and in the past (Limb et al., 2018). It is typical of a northern mixed-grass prairie that has been invaded by Kentucky bluegrass (*Poa pratensis* L.), and includes a

diverse forb community that should support a diverse pollinator community.

Agro-ecosystem management strategies that promote sustainable production and ecosystem services are dependent on practical solutions based on sound ecological principles. In rangelands, this research is complicated by the need for large-scale replication that is allowed to take place for multiple years. We have the unique situation of being able to take advantage of a tremendous amount of work (and financial cost) that already has been used to create four grazing management treatments that have each been replicated four times, each at a relatively large spatial scale (65-ha replicates).

Within this design framework, we compare four management treatments in their ability to optimize livestock production while promoting plant-pollinator interactions. Treatments are based on current management frameworks but use a combination of well-established and novel designs. The four treatments are (a) patch-burn grazing (PBG1) with one season of burn, (b) patch-burn grazing (PBG2) with two seasons of burn, (c) modified twice-over rest rotation grazing (MTRG) and (d) season-long grazing (SLG).

(a) Patch-burn grazing (PBG1) - one season of burn is a management framework that is intended to mimic historic disturbance regimes where focal grazing occurs on recently burned areas while lightly grazed areas allow for accumulation of plant biomass (fuel) for future fires (Fuhlendorf and Engle, 2001). Fires will occur in the spring of each year when fuel moisture levels have decreased sufficiently for fire to carry. Patch-burn pastures (approximately 65 ha each) are divided into four relatively equal-size patches (approximately 16 ha each), with one of the four patches being burned each spring. This four-year fire return interval is designed to mimic the historical disturbance regime of mixed-grass prairie.

(b) Patch-burn grazing (PBG2) - two seasons of burn. The season of burning can differentially alter how the plant community responds to fire (Kral et al., 2018). Moreover, considering multiple seasons can be important for promoting floristic diversity in grasslands and overcoming logistical challenges of spring-only fires (McGranahan et al., 2016). The second treatment is similar to the previous PBG treatment in that one-quarter of each pasture will be burned each year. However, in this case, half of a patch (a subpatch equal to one-eighth of a pasture, approximately 8 ha) is burned in the spring (same timing as PBG1) and the other subpatch is burned in the summer.

(c) Modified twice-over rest-rotation grazing (MTRG). Our third treatment is similar to the PBG treatments in that it is designed to produce structural heterogeneity across a grazing unit. However, unlike the PBG treatments, our modified twice-over rest-rotation grazing treatment utilizes fencing to dictate cattle distribution and influence grazing. The grazing unit is divided into four relative equal subpastures using cross-fences and grazed with one herd of cattle, grazing one pasture at a time from mid-May to late October. Cattle are rotated through each subpasture twice for a total of 155 days, a total of 74, 54, 27 and zero days the heavy use (60% to 80% disappearance), full use (40% to 60% disappearance), moderate use (20% to 40% disappearance) and rested subpastures, respectively. The first rotation uses 40% of the grazing days and the second rotation uses 60% of the available grazing days.

In subsequent years, grazing intensity will be rotated to different patches such that the full-use pasture will become the heavy-use pasture, the heavy-use pasture will transition to the rested pasture, the rested pasture to the moderate use and the moderate use to the full use. This rotation will create annual heavy disturbance in one subpasture and reduce annual heavy disturbance in the same location that could result in changes to forage quality and loss of plant species (Fuhlendorf et al., 2017).

(d) Season-long grazing (SLG) is intended to reflect “status quo” management for the region and will serve as a controlled comparison for the other treatments. This is a fairly typical management approach in this area and it serves as an important comparison because it homogeneously applies the disturbance (grazing) throughout the entire pasture. Thus, it is expected to lack the heterogeneity and structure of other treatments, and therefore not benefit biodiversity.

Common among the PBG1, PBG2 and SLG treatments, cow-calf pairs graze within pastures from mid-May to late October each year at a full-use stocking rate (1.01 animal unit months/acre) in all treatments designed to achieve an average 40% to 50% degree of disappearance across the pasture. The MTRG also was stocked at an average 1.01 animal unit months/acre across a four-cycle, 1.27 animal unit months/acre/year. Stocking rates were determined using a 25% and 30% harvest efficiency on the season-long and managed treatments, respectively. All treatments provide fresh water access and mineral supplements for cattle.

With the exception of MTRG, all treatment units (pastures) have exterior fencing only with no interior fences to separate individual patches. The MTRG uses interior fencing to separate patches and maintain livestock at a particular stocking rate throughout the year. Soil type and vegetation communities are similar among replicates as defined by Natural Resources Conservation Service (NRCS) ecological site descriptions and equivalent land-use histories (U.S. Department of Agriculture-NRCS, 2018).

Vegetation quadrat samples of 0.25 meters $(m)^2$ were used to determine the cover of native and introduced grasses and forbs. We also measured heights of vegetation, litter and thatch layers using 10 quadrats per survey set.

To determine herbage production and degree of disappearance, three 0.25 m^2 plots were caged and paired with three uncaged plots at each monitoring location (six total plots/monitoring site, 24 total plots per pasture) prior to the onset of grazing. At the peak of forage production for the year, in late July, two new plots were picked to match each of the original uncaged plots and the original plots and clipped using the 0.25 m^2 quadrats.

One of each pair of new plots was caged and at the end of the grazing period the herbage from each remaining plot were clipped. Herbage production clipped from inside caged plots at peak growing season provided an estimate of peak biomass.

The difference between biomass in the caged plots at the end of the grazing period and uncaged plots from the peak sampling represent the growth (or disappearance) from the peak. Samples were oven-dried to a constant weight and weighed to determine the amount of herbaceous production and percent utilization of the forage.

All cattle were weighed before they went on the pastures and again when they were removed using an average of two-day body weights. We quantified cow and calf performance by calculating daily weight gain of the calf and cow. This was determined by subtracting the average two-day weight at the beginning of the grazing season from the two-day weight at the end of the grazing season, then dividing by grazing days (about 155 days).

Results

Vegetation Degree of Disappearance

The degree of disappearance on the PBG treatments varies across the pasture based on timing of fire. The degree of disappearance ranged from 30.2% on the burn patches that were three-year post-fire to 75.3% on the new burns (Figure 1). Fairly high levels of disappearance occurred on the one-year post-fire sites at 59.5%. If all burn patches were similar in size, the average degree of disappearance on the PBG treatments would be 49.5%.

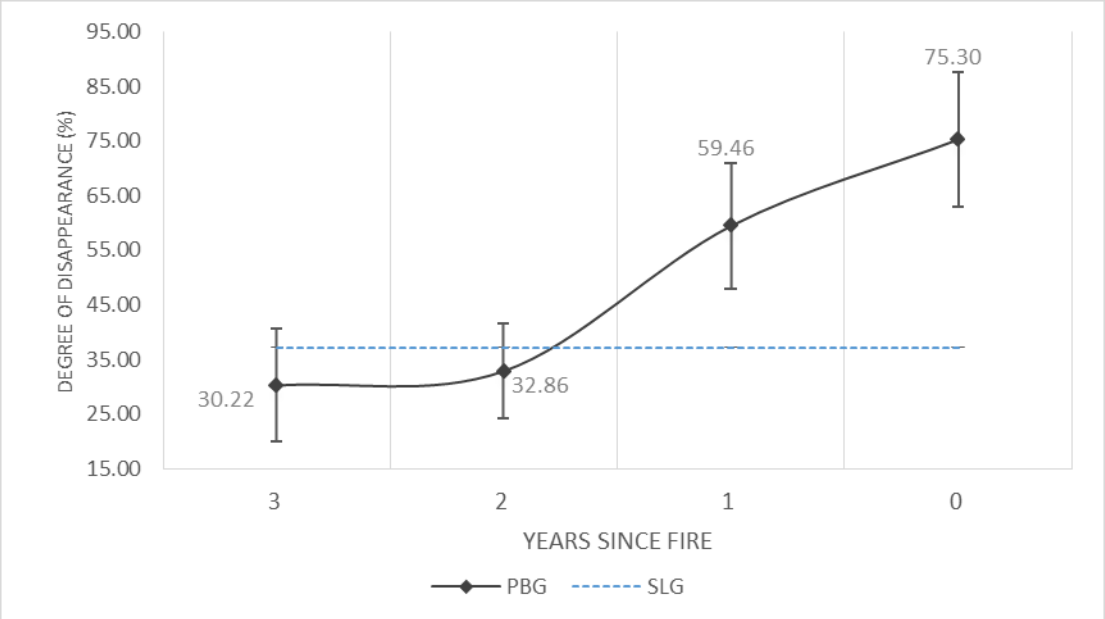

Figure 1. Average degree of vegetation disappearance of patches within patch-burn grazing treatments (PBG) arranged by time since fire, with season-long grazing (SLG) degree of disappearance shown as a baseline, at the Central Grasslands Research Extension Center near Streeter, N.D., in 2020.

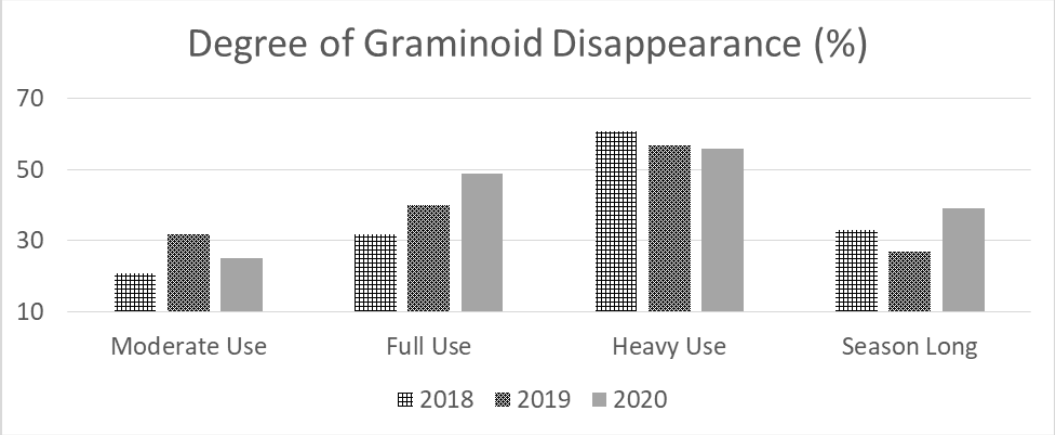

Figure 2. Degree of graminoid disappearance on the modified twice-over rotation and season-long treatments at the Central Grasslands Research Extension Center near Streeter, N.D.

The overall goal is to achieve an average degree of disappearance of 40% to 60% on the PBG, SLG and full-use pasture of the MTRG. We did meet this objective on the PBG and two years of the MTRG treatments but were slightly below the objective on SLG treatment during the four years at 37.2%.

The degree of disappearance of graminoid (grasses and sedges) on the modified twice-over rotation treatment was 21%, 32% and 61% in the moderate-, full- and heavy-use pastures in 2018, respectively (Figure 2). The degree of disappearance of graminoids was 32%, 40% and 59% in the moderate-, full- and heavy-use pastures in 2019, respectively.

The degree of disappearance of graminoids was 26%, 49% and 56% in the moderate-, full- and heavy-use pastures in 2020, respectively. Our full-use pasture was stocked to create a similar degree of disappearance as the SLG treatment, which averaged 33%, 27% and 39% in 2018, 2019 and 2020, respectively.

The 2018 and 2019 growing season precipitation was 127% and 136% of average, respectively (North Dakota Agricultural Weather Network, 2020). This additional precipitation resulted in higher than expected vegetation growth; thus, the degree of disappearance was below the targeted level.

In 2020, however, we were closer to achieving the desired degree on disappearance. We increased

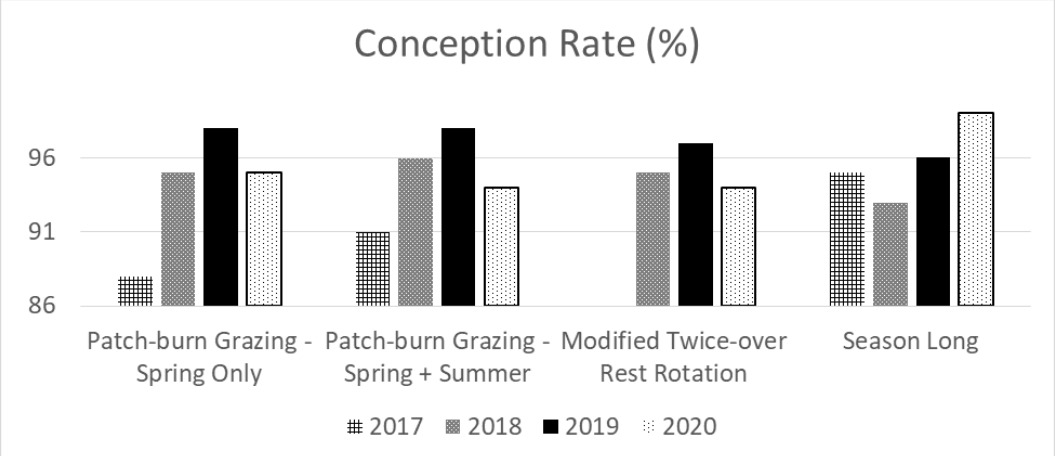

Figure 3. Conception rates of cows bred on pasture by grazing treatment at the Central Grasslands Research Extension Center near Streeter, N.D., from 2017 to 2020.

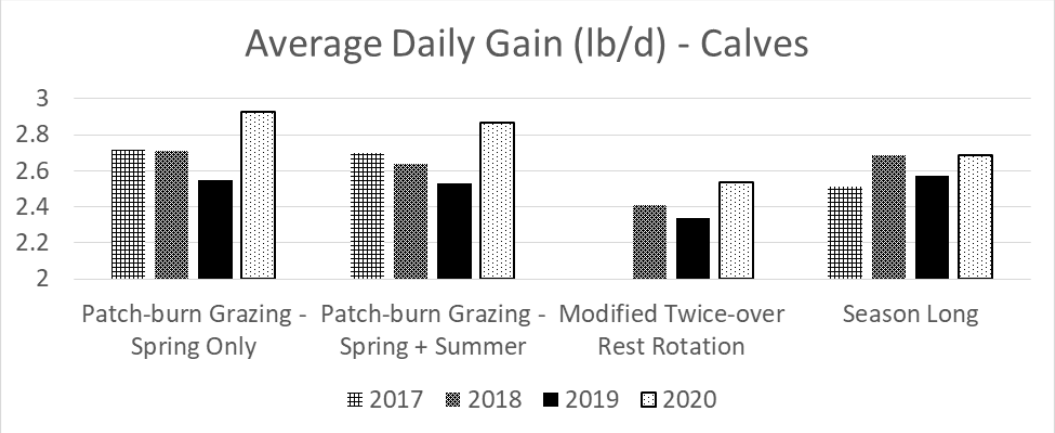

Figure 4. Calf average daily gain (pounds/day) by treatment at the Central Grasslands Research Extension Center near Streeter, N.D., from 2017to 2020.

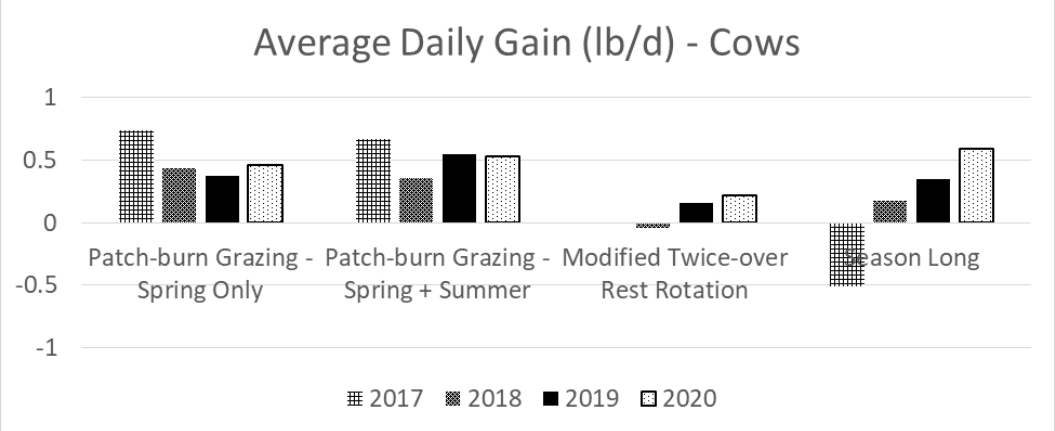

Figure 5. Cow average daily gain (pounds/day) by grazing treatment at the Central Grasslands Research Extension Center near Streeter, N.D., from 2017 to 2020.

animal numbers on the SLG treatment, adjusted grazing days on the MTRG and had a drought during the growing season, with only 58% of average rainfall.

Livestock Reproduction and Performance

The percent of bred cows was similar ($P > 0.05$) among treatments in all years of the study, ranging from 88% to 96% in 2017, 92% to 96% in 2018, 94% to 99% in 2019 and 94% to 96% in 2020, (Figure 3). On average, conception rates were 94%, 95%, 95% and 96% for the PBG1, PBG2, MTRG and SLG, respectively.

Calf performance, in terms of average daily gain, was similar ($P > 0.05$) among treatments in all four years (Figure 4). On average, calf average daily gain (pounds/day) was 2.72, 2.69, 2.43 and 2.62 on the PBG1, PBG2, MTRG and SLG, respectively.

Cow performance, in terms of average daily gain, was greatest ($P < 0.05$) on the PBG1 and PBG2 treatments in 2017, compared with the SLG (Figure 5). That year, the PBG treatments had positive average daily gains (0.72 and 0.67 pound/day), compared with cows losing weight on the SLG treatment (minus 0.51 pound/day).

In 2018, daily gains were higher ($P \leq 0.05$) on the PBG1 and PBG2 than the MTRG and SLG. Daily gains on the PBG1, PBG2 and SLG were different ($P \leq 0.05$) from the MTRG in 2018 and 2019 when compared with zero gain. We found no difference between treatments in cow performance in 2020.

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