Impacts of Patch Burn and Rotational Grazing to Create Heterogeneity in Grazing Patterns on Livestock Performance and Conception Rates on Kentucky Bluegrass-invaded Mixed-grass Prairie

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Summary
We monitored livestock performance and reproduction on four grazing strategies (patch-burn grazing - one season of burn, patch-burn grazing – two seasons of burn, modified twice-over rest-rotation grazing and season-long grazing). We observed no treatment effects on conception reproduction rates or calf average daily gain. However, cow average daily gain was highest on the two patch-burn grazing treatments, compared with the modified twice-over rest-rotation grazing in 2018 and 2019, and compared with the season-long grazing treatment in 2019.

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, Limb et al., 2011).

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 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 concentrates 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 and restore native species on Northern Great Plains rangelands and **2)** determine the effect of heterogeneity-based management on livestock production.

Methods

This study is 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 Agricultural Experiment Station, the CGREC's mission is to extend scientific research and Extension programming to the surrounding rural communities.

It consists of 5,335 acres 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 in the Missouri Coteau ecoregion of the northern Great Plains, which occupies 308 million acres, of which approximately 40% is perennial rangeland grazed by livestock. The Missouri Coteau ecoregion is characterized by irregular, rolling, rocky plains and depressional wetlands. The climate is characterized as temperate and experiences an average yearly rainfall of 15.9 inches (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, and includes a diverse forb community that could 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 management treatments that each have been replicated four times and each at a relatively large spatial scale (160-acre replicates).

Within this design framework, we compare four management treatments for 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 (PBG one season of burn), (b) patch-burn grazing (PBG two seasons of burn), and (c) modified twice-over rest rotation grazing (MTRR) and (d) season-long grazing (SLG)*.

(a) Patch-burn grazing - one season of burn (PBG1) is a management framework that is intended to mimic historic disturbance regimes in which focal grazing occurs on recently burned areas while lightly grazed areas allow for the 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 160 acres each) are divided into four relatively equal-size patches (approximately 40 acres each), with one of the four patches being burned each spring. These fire return intervals are designed to mimic the historical disturbance regime of mixed-grass prairie.

(b) Patch-burn grazing – two seasons of burn (PBG2) is a management framework that can differentially alter how the plant community responds to fire (Kral et al., 2018). Moreover, 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 PBG1 treatment in that one-quarter of each pasture will be burned each year. However, in this case, half of a patch (a sub-patch equal to one-eighth of a pasture - approximately 20 acres) is burned in the spring (same timing as PBG1) and the other half of that patch (the sub-patch = 1/8 of a pasture) is burned in the summer.

(c) Modified twice-over rest rotation grazing (MTRR). Our third treatment is similar to the PGB 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 utilized fencing to dictate cattle distribution and influence grazing. The grazing unit is divided into four relatively equal patches and cross-fenced to create four discrete sub-pastures that cattle cannot move between (without being moved purposefully) and grazed from mid-May to late October. Across the sub-pastures, cattle are rotated through twice and allowed to graze for a total 74, 54, 27 and zero days (total 155-day grazing season) in each rotation of the heavy use (60% to 80% disappearance), full use (40% to 60% disappearance), moderate use (20% to 40% disappearance) and rested sub-pastures, respectively. The first rotation uses 40% of the grazing days and the second rotation 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 full-use to the moderate-use pasture and rested to moderate grazing. This rotation will create annual heavy disturbance in one sub-pasture and reduce annual heavy disturbance in the same location, which 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 for this region and it serves as an important comparison because it homogeneously applies the disturbance (grazing) throughout the entire patch. Thus, it is expected to lack the heterogeneity and structure of other treatments, and therefore not benefit livestock.

Common among the four treatments, cow-calf pairs are grazed in pastures from mid-May to late October each year at a full-use stocking rate (1 animal unit month per acre) in all treatments designed to achieve a 40% to 60% degree of disappearance. 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 MTRR, all treatment units (pastures) have exterior fencing only with no interior fences to separate individual patches. The MTRR used interior fencing to separate patches and maintains livestock at a particular stocking rate throughout the year. Soil type and vegetation communities are similar among replicates, as defined by the Natural Resources Conservation Service (NRCS) ecological site descriptions and equivalent land-use histories (USDA-NRCS, 2018).

Vegetation quadrat samples will be performed using 0.5 x 0.5 meter (m) quadrats to determine the cover of native and introduced grasses and forbs. We also will measure the heights of vegetation, litter and thatch layers, and we will use 10 quadrats per survey set.

To evaluate the objectives, 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 mid-July, two new plots were picked to match each of the original uncaged plots and the original plots were clipped. One of each pair of new plots was caged, and at the end of the grazing period, the herbage from each remaining plot will be clipped.

Herbage clipped from inside caged plots at peak growing season provides an estimate of peak biomass. Differences 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 are 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 the cattle were removed. We quantified their performance management treatments by measuring weight gain of the calf and cow, and reproductive success of the cow.

Calves were weighed within 24 hours of birth, on the day they were delivered to a treatment and again, using a 2-day weight, when weaned at the end of the grazing season. The difference in those weights provided calf total and daily weight gain. Two-day individual body weights of cows were measured at the beginning and end of the grazing season, with that difference providing a measurement of cow weight gain. Cows were bred via artificial insemination on their first cycle, with bulls placed on pasture one week after artificial insemination to service cows not bred on the first cycle.

Bulls remained with the cows for two cycles, or about 45 days. Cows were pregnancy checked at the end of the grazing season to measure reproduction success.

Results

(a) Vegetation Degree of Disappearance

Within the PBG1 and PBG2 treatments, the degree of disappearance of the standing crop average was 53%, 42%, 35% and 34% in the current year burned, one post-burned, two years post-burned and non-burned patches in 2019 (Figure 1). The average degree of disappearance of the standing crop on the SLG was 33% and 27% in 2018 and 2019, respectively (Figures 1 and 2).

Within the modified twice-over rotation rest rotation treatment, the degree of disappearance of graminoids (grasses and sedges) 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 31%, 40% and 57% in the moderate-, full- and heavy-use pastures in 2019, respectively (Figure 2).

Our full-use pasture was stocked to create a similar degree of disappearance as the season-long treatment, which averaged 33%. The goal is to achieve a degree of disappearance on the season-long treatment and full-use pasture of 40% to 50%; however, the 2018 and 2019 growing season precipitation was 127% and 136% of average; respectively. This additional precipitation created higher than expected vegetation growth; thus, the degree of disappearance was below the targeted level.

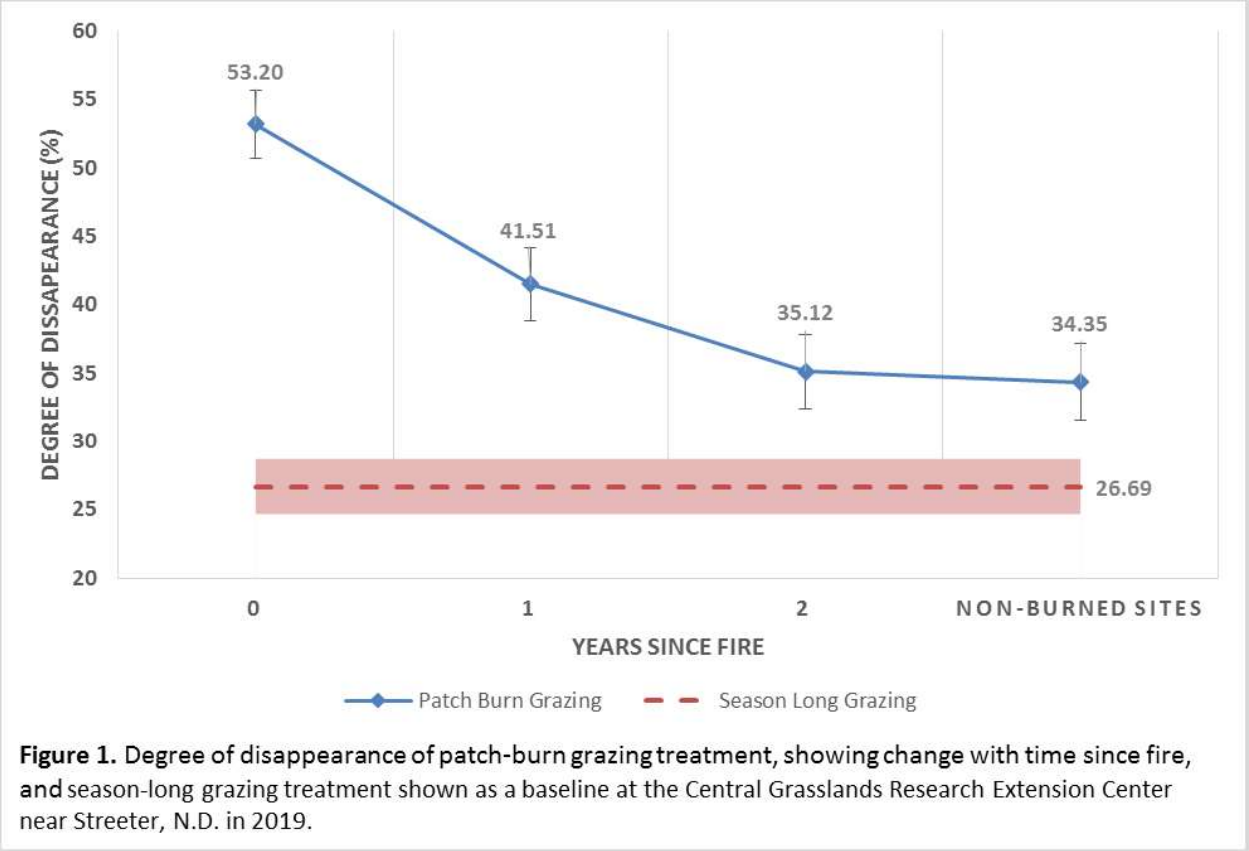

Figure 1. Degree of disappearance of patch-burn grazing treatment, showing change with time since fire, and season-long grazing treatment shown as a baseline at the Central Grasslands Research Extension Center near Streeter, N.D. in 2019.

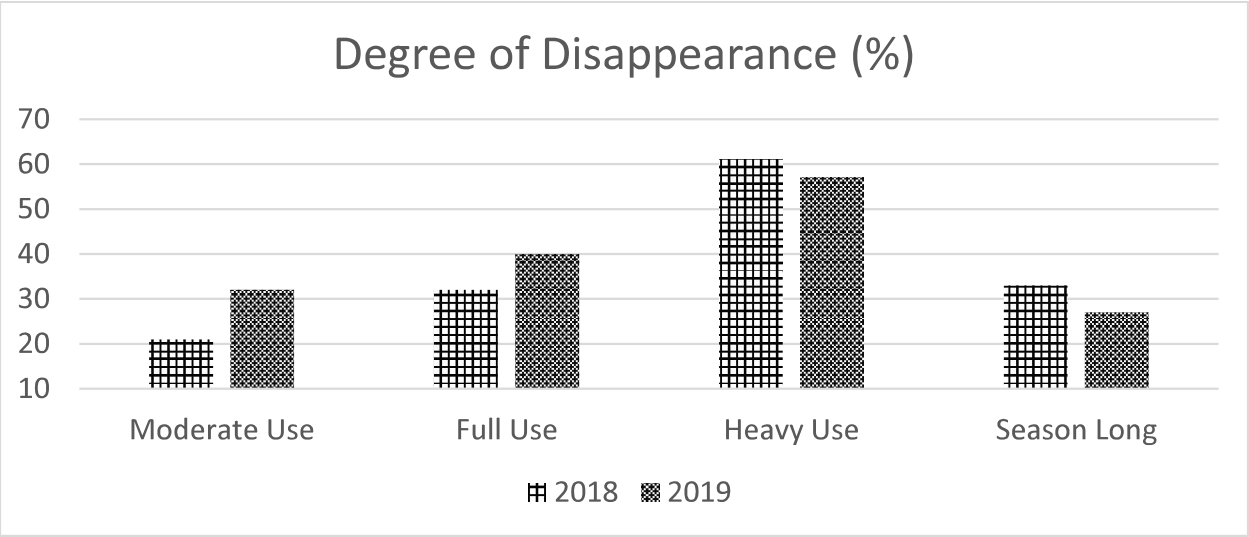

Figure 2. Degree of disappearance on the modified twice-over rest rotation treatment at the Central Grasslands Research Extension Center near Streeter, N.D., in 2018.

(b) Livestock Performance

The percent of bred cows was similar (P > 0.05) among treatment in all years of the study, ranging from 88% to 96%, 92% to 96% and 96% to 98% in 2017, 2018 and 2019, respectively (Figure 3). The three-year average for percent conception rate was 94, 95, 95 and 96 on the PBG1, PBG2, SLG and MTRR, respectively.

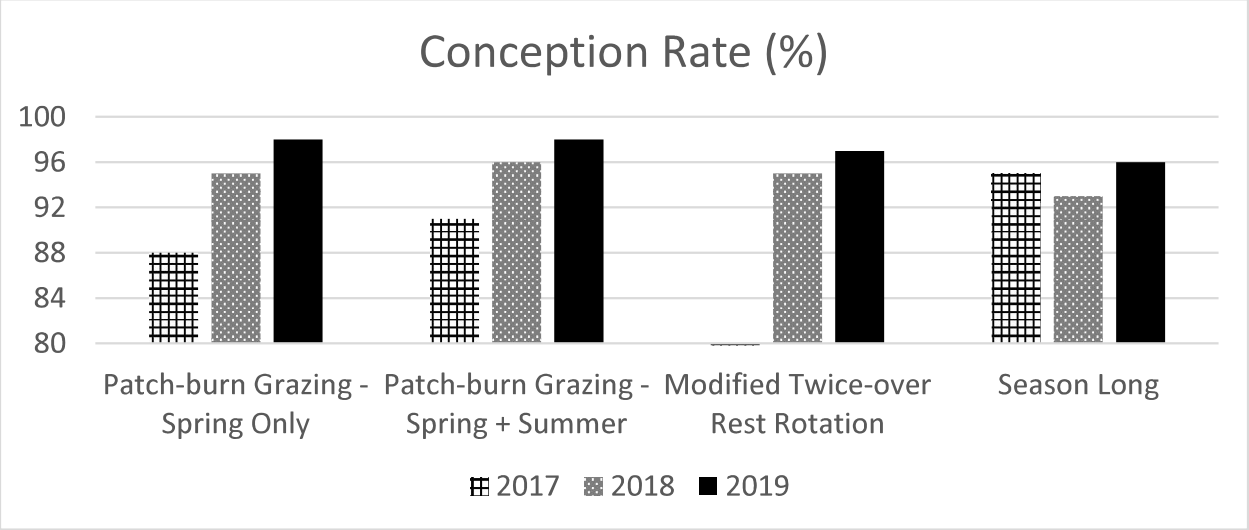

Figure 3. Conception rates of cows bred on pasture by treatment at the Central Grasslands Research Extension Center near Streeter, N.D., in 2017, 2018 and 2019.

Calf performance, in terms of average daily gain, was similar (P > 0.05) among all treatments all years of the study (Figure 4). Calf average daily gain (pounds/day) ranged from 2.34 on the MTRR in 2019 to 2.71 on the PBG1 in 2017. The three-year average for calf average daily gain was 2.38, 2.6, 2.62 and 2.66 on the MTRR, SLG, PBG2 and PBG1, respectively.

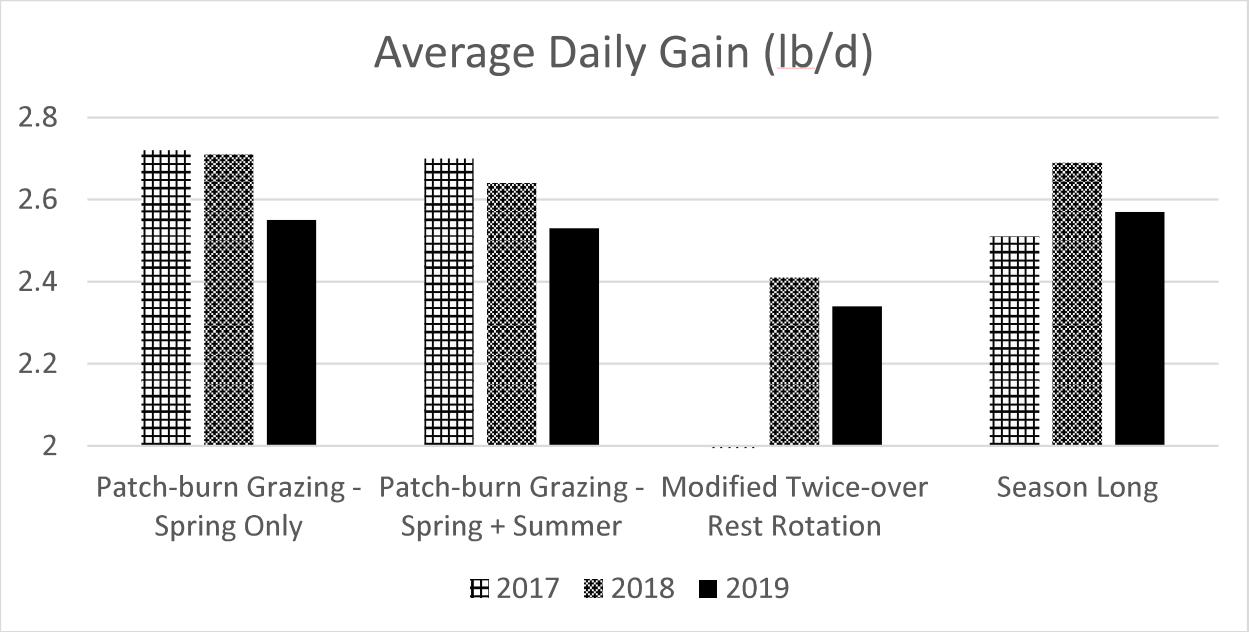

Figure 4. Calf average daily gain (pounds/day) by treatment at the Central Grasslands Research Extension Center near Streeter, N.D., in 2017, 2018 and 2019.

Although cows had a positive daily weight gain on PBG1 and PBG2 (0.67 and 0.72 pound/day), compared with the SLG losing weight (minus 0.51 pound/day) in 2017, we found no significant differences ($P > 0.05$) due to a high degree of variability (Figure 5). However, cow performance, in terms of average daily, was greatest ($P \leq 0.05$) on the PBG1 and PBG2, compared with the SLG and MTRR, in 2018, and compared with MTRR in 2019 (Figure 5). The three-year average for cow average daily gain was 0.52, 0.53, 0.06 and 0.01 on the PBG1, PBG2, MTRR and SLG, respectively.

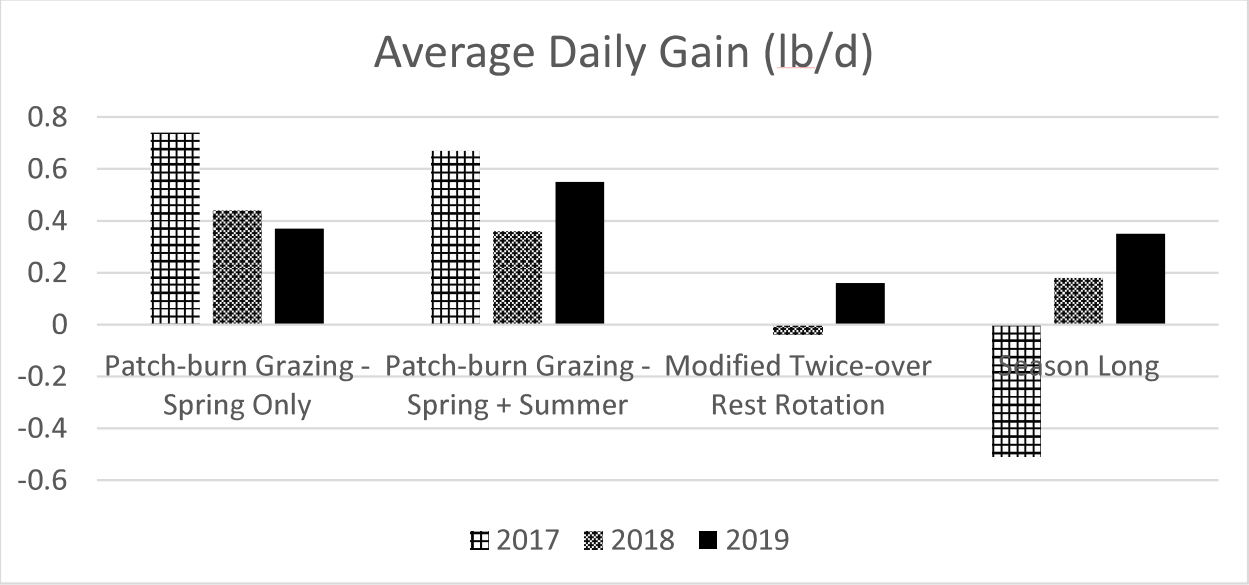

Figure 5. Cow average daily gain (pounds/day) by treatment at the Central Grasslands Research Extension Center near Streeter, N.D., in 2017, 2018 and 2019.

Literature Cited

Churchwell, R.T., C.A. Davis, S.D. Fuhlendorf and D.M. Engle. 2008. Effects of patch-burn management on dickcissel nest success in a tallgrass prairie. *Journal of Wildlife Management* 72:1596-1604.

Coppedge, B.R., S.D. Fuhlendorf, W.C. Harrell and D.M. Engle. 2008. Avian community response to vegetation and structural features in grasslands managed with fire and grazing. *Biological Conservation* 141:1196-1203.

Dunn, B.H., A.J. Smart, R.N. Gates, P.S. Johnson, M.K. Beutler, M.K. Diersen and L.L. Janssen. 2010. Long-term production and profitability from grazing cattle in the northern mixed grass prairie. *Rangeland Ecology and Management* 63:233–242.

Engle, D.M., S.D. Fuhlendorf, A. Roper and D.M. Leslie Jr. 2008. Invertebrate community response to a shifting mosaic of habitat. Rangeland Ecology and Management 61:55-62.

Fuhlendorf, S.D., and D.M. Engle. 2001. Restoring heterogeneity on rangelands: ecosystem management based on evolutionary grazing patterns. *Bioscience* 51:625–632.

Fuhlendorf, S.D., and D.M. Engle. 2004. Application of the fire-grazing interaction to restore a shifting mosaic on tallgrass prairie. *Journal of Applied Ecology* 41:604–614.

Fuhlendorf, S.D., W.C. Harrell, D.M. Engle, R.G. Hamilton, C.A. Davis and D.M. Leslie Jr. 2006. Should heterogeneity be the basis for conservation? Grassland bird response to fire and grazing. *Ecological Applications* 16:1706–1716.

Fuhlendorf, S.D., D.E. Townsend II, R.D. Elmore and D.M. Engle. 2010. Pyric–herbivory to promote rangeland heterogeneity: evidence from small mammal communities. *Rangeland Ecology & Management* 6:670–678.

Fuhlendorf, S.D., R.W.S. Fynn, D.A. McGranahan and D. Twidwell. 2017. Heterogeneity as the basis for rangeland management, in: Briske, D.D. (Ed.), Rangeland Systems: Processes, Management and Challenges, Springer Series on Environmental Management. Springer International Publishing, pp. 169–196.

Kral, K.C., R. Limb, A. Ganguli, T. Hovick and K. Sedivec. 2018. Seasonal prescribed fire variation decreases inhibitory ability of *Poa pratensis* L. and promotes native plant diversity. *Journal of Environmental Management* 223:908-916.

Limb, R.F., T.J. Hovick, J.E. Norland and J.M. Volk. 2018. Grassland plant community spatial patterns driven by herbivory intensity. *Agriculture Ecosystems & Environment* 257:113-119.

Limb, R.F., S.D. Fuhlendorf, D.M. Engle, J.R. Weir, R.D. Elmore and T.G. Bidwell. 2011. Pyric–Herbivory and Cattle Performance in Grassland Ecosystems. *Rangeland Ecology and Management* 64(6):659-663.

O'Connor, T.G., P. Kuyler, K.P. Kirkman and B. Corcoran. 2010. Which grazing management practices are most appropriate for maintaining biodiversity in South African grassland? *African Journal of Range and Forage Science* 27:67–76.

USDA-NRCS. 2018. U.S. Department of Agriculture-Natural Resource Conservation Service. Web Soil Survey. http://websoilsurvey.nrcs.usda.gov. Accessed Oct. 29, 2018.