Aboveground Cumulative Production with Rotational Grazing: Assessing a Modified Twice-over Rest-rotation Treatment

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Summary

Aboveground cumulative production accounts for any additional plant growth that occurs from regrowth following a grazing event plus growth consumed by the animal during the grazing event.

Rotational grazing that created a recovery period of 33 days from grazing between the first rotation and second rotation of the modified twice-over rest-rotation treatment (MTRR) increased the aboveground cumulative production on the heavy use sub-pasture by 56.1% and 43.3% on the loamy and shallow loamy ecological site, compared with nonuse exclosures in 2018. The degree of disappearance was at 63% and 65%, respectively, at the end of the first rotation.

In 2019, the heavy-use sub-pasture had an increased above-ground net primary production of 60.9% and 48.8% on the loamy and shallow loamy ecological site, compared with nonuse exclosures with a 33-day recovery period from grazing and degree of disappearance at 55% and 53%, respectively, after the first rotation.

The full-use sub-pasture had an increased above-ground net primary production of 20.1% and 20.6% on the loamy and shallow loamy ecological site, compared with nonuse exclosures in 2019 with 60 days recovery and degree of disappearance of 29% and 25%, respectively, after the first rotation. The moderate-use sub-pasture had an increased aboveground cumulative production of 5.9% and 8.1% on the loamy and shallow loamy ecological site, compared with nonuse exclosures in 2019, with 79 days recovery and degree of disappearance at 16% and 20%, respectively, after the first rotation.

The recovery period does not appear to be the driving factor in growth efficiency, but the degree of disappearance during the first half of the growing season and uniformity of use during the first rotation is what creates greater regrowth across the pasture, thus increasing growth efficiency potential.

Introduction

Grazing systems differ from season-long grazing through stocking rates, stocking density, and timing of grazing and livestock distribution (Holechek et al., 1998; Smart et al., 2010). Typically, season-long and rotational-grazing systems differ in stocking rates and temporal and spatial manipulation of grazing (Savory, 1988), creating a high stock density.

Rotational grazing is believed to be a superior way to manage resources, especially at the ranching level on private lands (Ranellucci et al. 2012). However, relatively few studies support this concept that rotational grazing systems are superior to other management regimes (Hart et al., 1993; Manley et al., 1997; Briske et al., 2008).

The disconnect with the science and anecdotal success ranchers have using rotational grazing leads to these questions: Why do ranchers find success with rotational grazing systems but the science shows no superior benefits with forage production or livestock performance? Does the science address the proper question or did the methodologies used in previous studies lack the rigors in collecting the proper outputs?

Given the controversy surrounding the benefits of grazing regimes, evaluating the effects of season-long and rotational-grazing systems using a more rigorous data collection approach can provide us with recommendations for range and pasture management in the Northern Great Plains (NGP).

Twice-over rotation grazing is promoted widely in the NGP and humid northeastern Great Plains (Sedivec and Barker, 1991; Biondini and Manske, 1996; Shepherd and McGinn, 2003; Limb et al., 2018). Twice-over grazing, like many rotational grazing systems, is a practical application of the grazing optimization hypothesis (McNaughton, 1979).

It is designed to increase productivity and forage availability by defoliating plants at particular phenological stages and stimulate vegetative tillering while delaying or reducing reproductive culm development when grazed prior to the head development stage (Milchunas et al., 1988; Biondini and Manske, 1996). This grazing process is believed to increase aboveground cumulative production, ultimately allow greater stocking rates and economic returns (Biondini and Manske, 1996).

Previous rotational grazing studies were designed to create a homogenous grazing pattern throughout the unit or system, attempting to create the greatest impact of the vegetation during the immature phenological growth stage (prior to the heading stage; Briske et al., 2008; Smart et al., 2010). However, most of the studies lack the methodology or rigors of vegetative data collection to show how much regrowth occurred and how much forage was consumed throughout the grazing season (Briske et al., 2008).

To determine aboveground cumulative production, these parameters (regrowth and consumption) need to be assessed to truly determine the impact of a rotational grazing on forage production potential and economic return.

Heterogeneity is the principal driver of biodiversity in rangeland ecosystems and frequently is correlated positively with population and community stability (Wiens, 1997; Hovick et al., 2015; McGranahan et al., 2016). As most rotational grazing systems used by ranchers today, and most published in the literature, were designed to create spatially uniform moderate grazing, they often failed to create sufficient habitat heterogeneity to support species with requirements at both extremes of the vegetation structure gradient, thus constraining potential biodiversity (Knopf, 1994; Fuhlendorf et al., 2006).

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; Limb et al. 2011). Patch-type grazing is needed to create a structurally and compositionally heterogeneous landscape.

Therefore, this project will focus on determining the effect of heterogeneity-based management within an exotic perennial cool-season-invaded rangeland on 1) aboveground cumulative production, 2) livestock performance and 3) plant community composition.

Study Area and Design

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). The CGREC's mission is to extend scientific research and Extension programming to the surrounding rural communities.

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.

Within this design framework, we compare four management treatments for their ability to optimize forage production (aboveground cumulative production) and livestock production while promoting plant-pollinator and breeding bird 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), (c) modified twice-over rest-rotation grazing (MTRR) and (d) season-long grazing (SLG)*. The MTRR and SLG treatments will be assessed in this report for aboveground cumulative production. Each treatment was replicated four times using a block design.

<u>Modified twice-over rest-rotation grazing (MTRR)</u> treatment was designed to be similar to patch-burn grazing (PBG) in that it is designed to produce structural heterogeneity across a pasture. 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 freely move between and are grazed from mid-May to late October. Cattle are rotated twice across the sub-pastures, 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 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 moderate-use to the heavy-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).

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.

Common among the treatments, cow-calf pairs are grazed within 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.

The MTRR used 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 (USDA-NRCS, 2018). Vegetation clipping samples were oven-dried to a constant weight and weighed to determine the amount of herbaceous production and degree of disappearance of the forage.

Methodology

Vegetation quadrat samples will be performed using 0.25 m^2 quadrats to determine production of standing crop, graminoids (grasses and sedges) and forbs. To evaluate objectives, five cages were placed on two loamy and two shallow loamy ecological sites in each sub-pasture (heavy, full, moderate, rested) of the MTRR (20 cages total per sub-pasture).

We used the pair-plot clipping technique and clipped one plot per cage in the cage and its paired plot outside the cage at the end of each grazing period within a sub-pasture during the first rotation. The herbage production inside the cage represents the amount of the growth produced when cattle were moved to a new sub-pasture. The degree of disappearance and herbage production consumed by cattle is determined from the difference between growth in the caged plots and uncaged plot.

Herbage production is collected inside the cage and from a new paired uncaged plot for a second time when cattle are moved back into a sub-pasture during the second rotation. This growth represents continued growth from the first clipping (first grazing event) without grazing (inside cage) and regrowth with grazing (outside cage).

At the end of each second grazing event, herbage production is clipped for the third time inside the cage to represent total herbage production and outside the cage using a new paired plot to determine overall degree of disappearance by sub-pasture use and herbage production consumed by cattle during the second grazing period. Aboveground cumulative production was calculated for each grazing intensity level (sub-pastures) by totaling the herbage production at the end of the second grazing period (outside cage) with the amount of production consumed by cattle at the end of the second grazing period (inside cage minus outside cage) plus regrowth (second outside cage clipping minus first outside cage) plus the amount of production consumed by cattle at the end of the first grazing period (inside cage minus outside cage).

Herbage production was clipped monthly (June through October) during the third week in the rested pasture to determine peak herbage production. October was chosen as the last month to clip because the growing season ended Oct. 10, 2019 (28 F for two-plus hours). The aboveground cumulative production from each grazing intensity sub-pasture was compared with the peak herbage production from the rested pasture.

Vegetative data collection on the SLG used the same technique, except 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 (totaling five plots per site; same for the MTRR).

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 peak.

Results

In 2018, we only determined aboveground cumulative production for the heavy-use sub-pasture on the loamy and shallow loamy ecological sites. Aboveground cumulative production on the heavy-use sub-pasture was 56.1% and 43.3% greater than the non-grazed paired plots on the loamy and shallow loamy ecological sites; respectively (**Figures 1** and **2**).

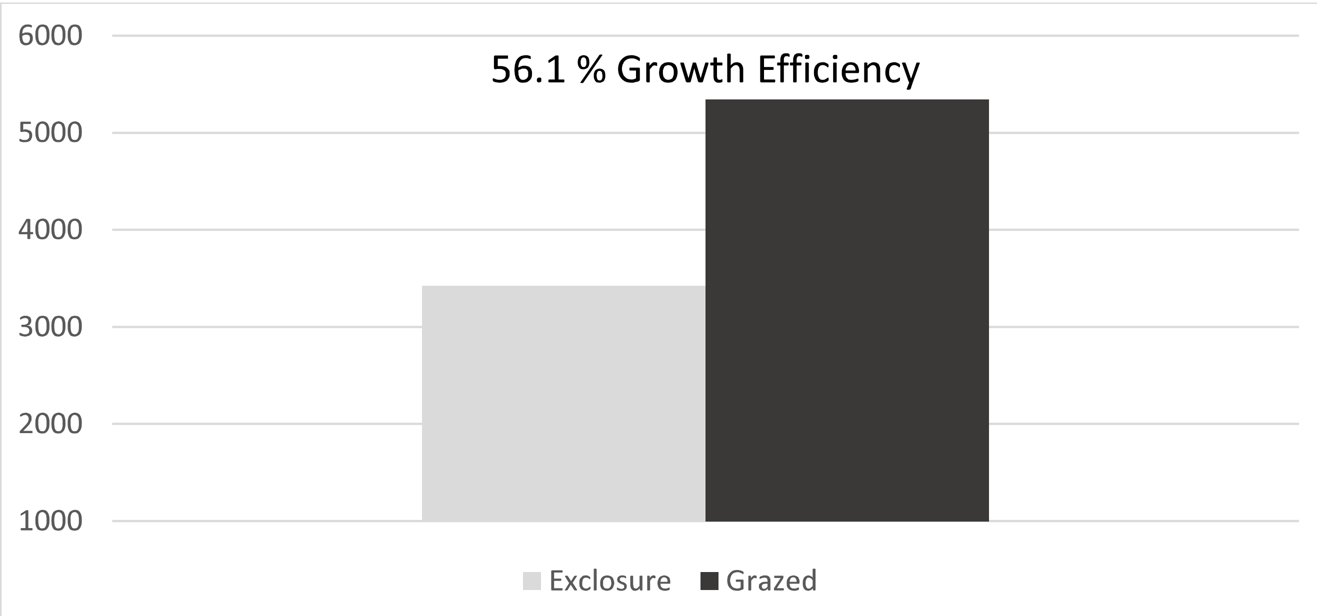

Figure 1. Above-ground net primary production on the heavy-use grazing intensity sub-pasture within the exclosures (non-grazed plots) and grazed plots, and growth efficiency on the loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2018.

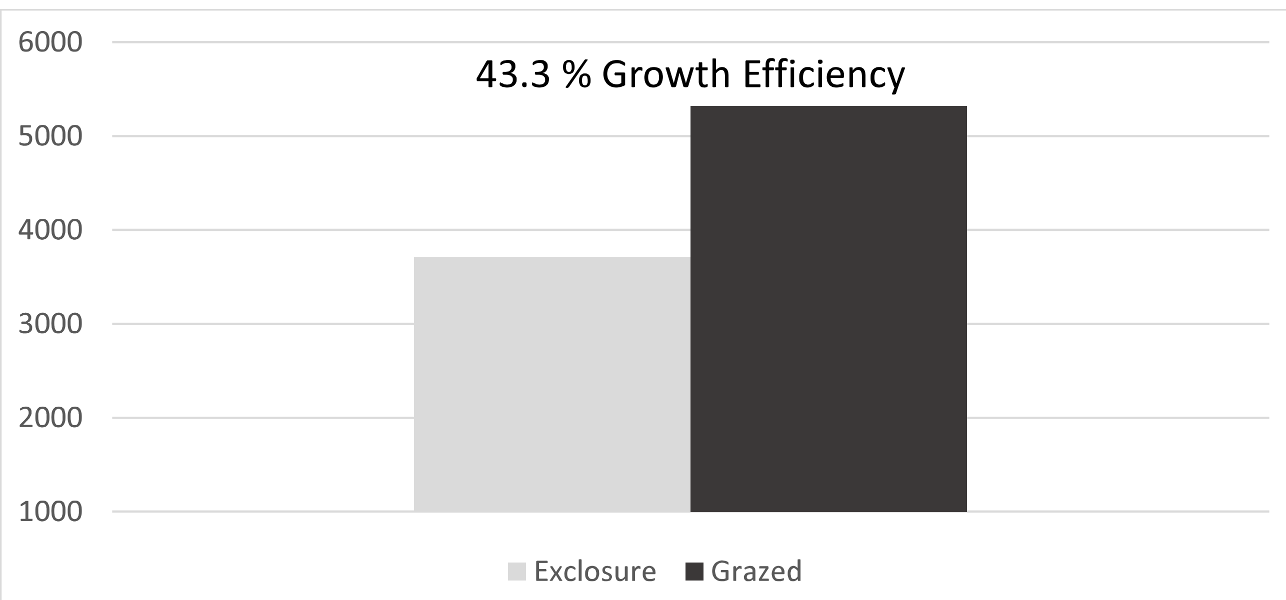

Figure 2. Above-ground net primary production on the heavy-use grazing intensity sub-pasture within the exclosures (non-grazed plots) and grazed plots, and growth efficiency on the shallow loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2018.

In 2019, all sub-pastures were collected to determine aboveground cumulative production to determine if grazing intensity impacts growth efficiency. Aboveground cumulative production on the heavy-use sub-pasture was 60.9% and 48.8% greater than the non-grazed paired plots on the loamy and shallow loamy ecological sites, respectively (**Figures 3** and **4**).

Growth efficiency declined with reduced grazing intensity. Aboveground cumulative production on the full-use sub-pasture was 20.1% and 20.6% greater than the non-grazed paired plots on the loamy and shallow loamy ecological sites, respectively (**Figures 3** and **4**). Aboveground cumulative production on the moderate-use sub-pasture was 5.9% and 8.1% greater than the non-grazed paired plots on the loamy and shallow loamy ecological sites, respectively (**Figures 3** and **4**).

What should be noted is that overall growth efficiency on the full- and moderate-use sub-pastures was lower due to the forbs or lack of regrowth and consumption of the forbs on the grazed plots. Graminoid growth efficiency was 21.1% and 22.2% for the full- and moderate-use sub-pastures, respectively, on the loamy ecological site and 32.2% and 15.2% for the full- and moderate-use sub-pastures, respectively, on the shallow ecological site (data not shown).

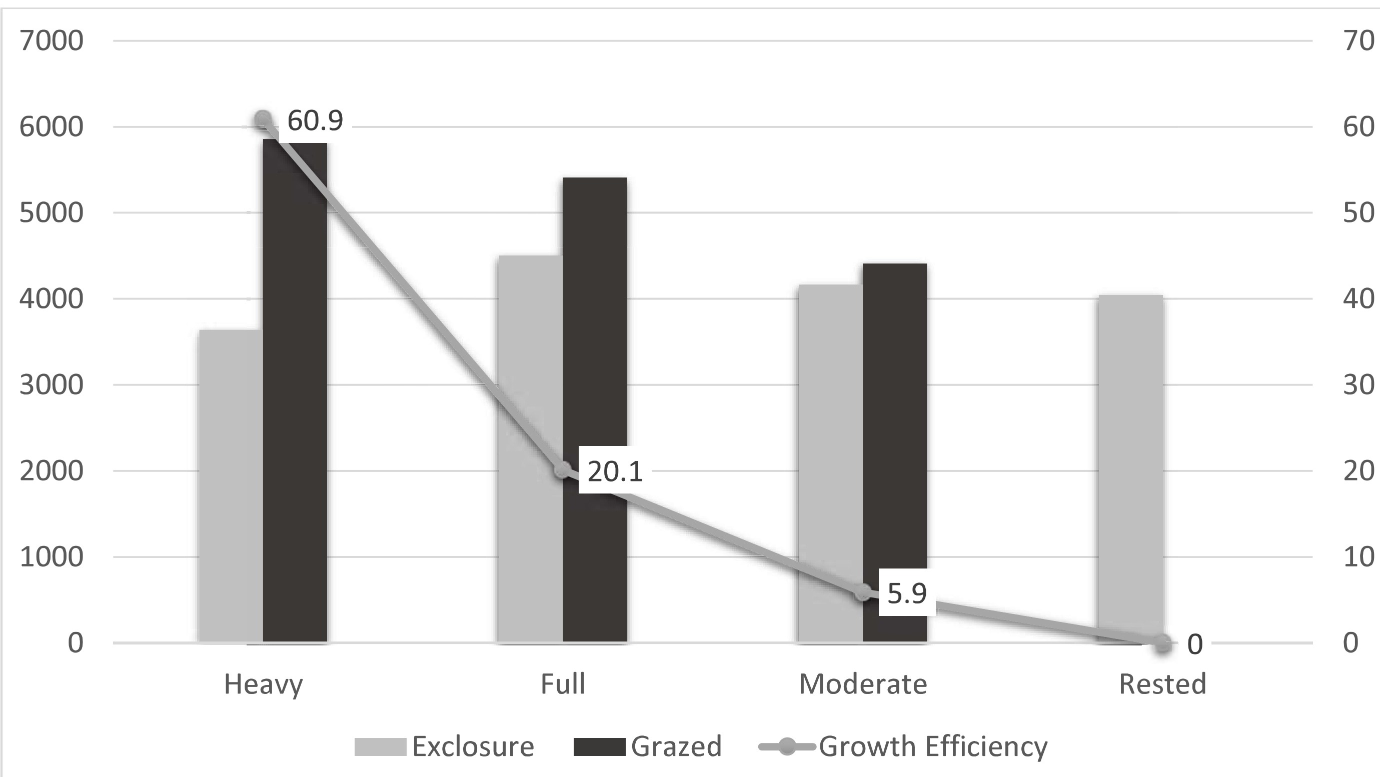

Figure 3. Above-ground net primary production by grazing intensity within the exclosures (non-grazed plots) and grazed plots, and growth efficiency on the loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2019.

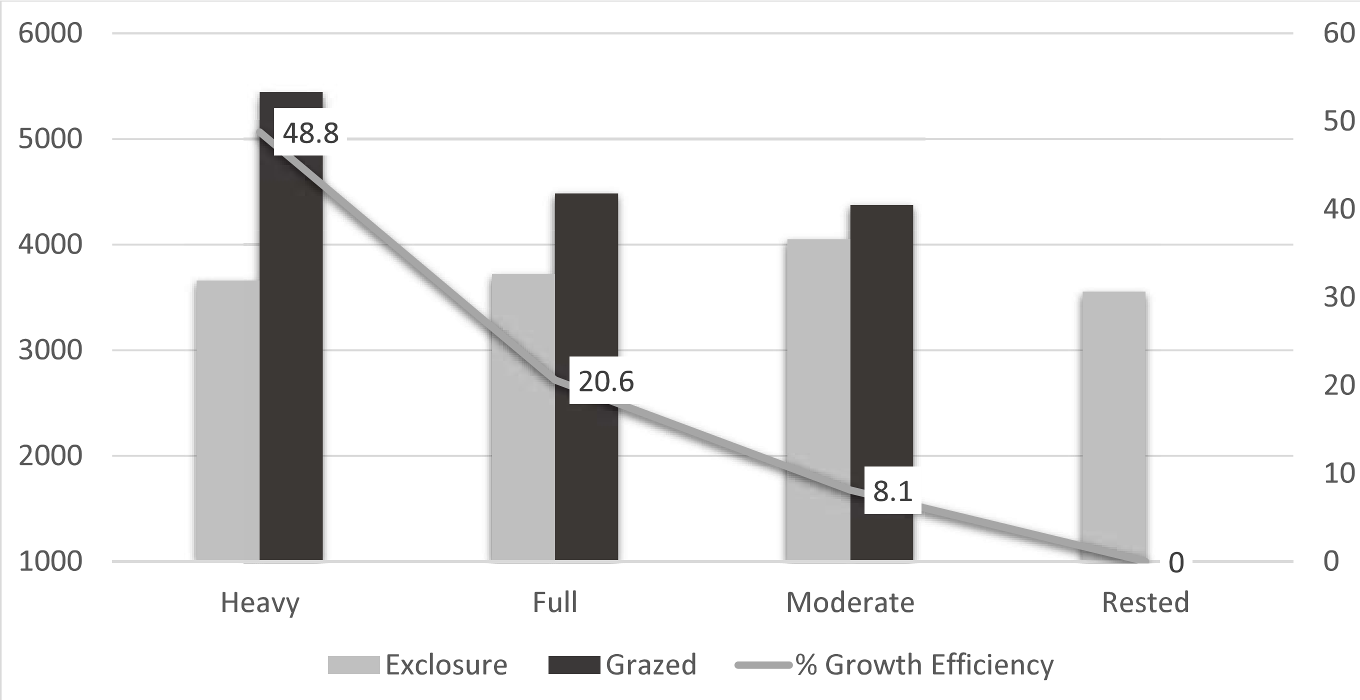

Figure 4. Above-ground net primary production by grazing intensity within the exclosures (non-grazed plots) and grazed plots, and growth efficiency on the shallow loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2019.

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