How Does a Grazing System Work? Above-ground Cumulative Production and Growth Efficiency with a Modified Twice-over Rest-rotation Treatment

Kevin Sedivec[1,2], Erin Gaugler[2], Michael Hamel[1], Ryan Limb[1], Devan McGranahan[1] and Torre Hovick[1]

[1]North Dakota State University School of Natural Resource Sciences, Range Science Program, Fargo, N.D.

[2]North Dakota State University Central Grasslands Research Extension Center, Streeter, N.D.

Summary

Above-ground 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 with 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 and growth efficiency. On the heavy-use subpasture, cumulative production increased by 51.8%, 66.6% and 35.5% on the loamy and 50%, 54.3% and 47.9% on the shallow loamy ecological sites, compared with peak production from the nonuse exclosures in 2018, 2019 and 2020, respectively. The overall degree of disappearance was at 64.9%, 57.2% and 56.2% for those years, respectively.

On the full-use subpasture, we had an increased above-ground cumulative production of 40.8% and 24.7% on the loamy and 36.6% and 60.8% on the shallow loamy ecological site, compared with peak production from the nonuse exclosures in 2019 and 2020, respectively. This subpasture treatment received 60 days of recovery between the first and second rotation. The overall degree of disappearance was 39.8% and 49.7%, respectively, after the second rotation.

On the moderate-use subpasture, we had an increased above-ground cumulative production of 26.7% and 20.1% on the loamy and 29.7% and 30.1% on the shallow loamy ecological site, compared with peak production from the nonuse exclosures in 2019 and 2020, respectively. This subpasture treatment received 79 days of recovery between the first and second rotation. The overall degree of disappearance was 31.7% and 24.8% after the second rotation (end of grazing season).

The length of recovery period did not appear to be the driving factor in growth efficiency, but the degree of disappearance and the uniformity of use create greater regrowth across the pasture, thus increasing growth efficiency potential.

Introduction

Grazing systems differ from season-long grazing through the increased control over 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 the concept that rotational grazing systems are superior to other management regimes (Hart et al., 1993; Manley et al., 1997; Briske et al., 2008).

Twice-over rotation grazing is promoted widely in the northern Great Plains 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).

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, that is, 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 above-ground cumulative production, these parameters (regrowth and consumption) need to be assessed to truly determine the impact of 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., 2010). 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) above-ground cumulative production, 2) growth efficiency, 3) livestock performance and 4) 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 (*Poa pratensis* L.) and includes a diverse forb community that supports a diverse pollinator community.

Within this design framework, we compare four management treatments for their ability to optimize forage production (above-ground 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: patch-burn grazing (PBG, one season of burn), patch-burn grazing (PBG, two seasons of burn), modified twice-over rest-rotation grazing (MTRR) and season-long grazing (SLG). Each treatment is replicated four times using a block design. This article will focus on the MTRR treatment.

The MTRR treatment was designed to be similar to patch-burn grazing (PBG) in that it produces structural heterogeneity across a pasture. 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 relatively equal patches and cross-fenced to create four discrete subpastures that cattle cannot freely move between and are grazed from mid-May to late October. Cattle are rotated twice across each of the subpastures and allowed to graze for a total 74, 54, 27 and zero days (total 155-day grazing season) in the heavy use (60% to 80% disappearance), full use (40% to 60% disappearance), moderate use (20% to 40% disappearance) and rested subpastures, respectively. Cattle start the grazing season in the heavy-use subpasture.

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 pasture. This rotation will create annual heavy disturbance in one subpasture 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).

Cow-calf pairs are grazed within pastures from mid-May to late October each year. The stocking rate is determined assuming a 30% harvest efficiency. Fresh water access from well water and mineral supplements are provided.

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).

Methodology

Vegetation quadrat samples are collected using 0.25 meter $(m)^2$ quadrats to determine production of standing crop, graminoids (grasses and sedges) and forbs. Samples are oven-dried to a constant weight and weighed.

To evaluate objectives, five cages are placed on two loamy and two shallow loamy ecological sites in each subpasture (heavy, full, moderate, rested) of the MTRR (20 cages total per subpasture).

Herbage production is determined during the first rotation using the pair-plot clipping technique, with one plot clipped in the cage and a paired plot outside the cage clipped at the end of each grazing period. The herbage production inside the cage represents the amount of the growth produced in the first rotation. The degree of disappearance and herbage production consumed by cattle is determined from the difference between growth in the caged plot and uncaged plot.

Herbage production is collected again after the rest period and prior to cattle grazing the second rotation by clipping inside the cage and from a new paired uncaged plot. This growth represents continued growth from the first clipping (first grazing event) without grazing (inside cage) and regrowth after grazing (outside cage).

At the end of the second rotation, 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 and herbage production consumed by cattle during the second grazing period.

Herbage production is clipped monthly (June through October) during the third week of the month in the rested pasture to determine peak herbage production. Peak production is the highest amount of production present during the growing season. Net primary production is production at the end of the grazing season. If peak production occurs at the end of the grazing season, then peak production and net primary production are the same, meaning no senescence occurred during the grazing season.

Above-ground cumulative production is calculated for each grazing intensity level (subpasture) 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) plus senescence (peak production minus net primary production) (see below).

Cumulative production =

livestock consumption during first rotation
(production inside exclosure – production outside exclosure)

+ regrowth during the rest period
(production outside exclosure prior to second rotation – production outside exclosure after the first rotation)

+ livestock consumption during second rotation
(production inside exclosure – production outside exclosure)

+ senescence[1]
(peak production – net primary production)

[1] *If peak production occurred at the end of the grazing period, then it would be equal to net primary production, and senescence = zero.*

$$\textbf{Growth efficiency} = \frac{\text{cumulative production} - \text{peak production}}{\text{peak production}} \times 100\%$$

The above-ground cumulative production from each grazing intensity subpasture is compared with the peak herbage production from within the same grazing intensity subpasture to determine growth efficiency.

Results

In 2018, we determined above-ground cumulative production for only the heavy-use subpasture. Above-ground cumulative production was 51.8% and 50.0% greater than peak production from the non-grazed plots on the loamy and shallow loamy ecological sites, respectively (Figures 1 and 2).

In 2019 and 2020, all subpasture treatments (heavy, full and moderate) were studied to determine if grazing intensity impacts growth efficiency. Above-ground cumulative production on the heavy-use subpasture was 66.6% and 54.3% greater in 2019 and 35.5% and 47.9% greater in 2020, compared with peak production from the non-grazed plots on the loamy and shallow loamy ecological sites, respectively. (Figures 1 and 2).

Generally, growth efficiency declined with reduced grazing intensity. Above-ground cumulative production on the full-use subpasture was 40.8% and 36.6% greater in 2019, and 24.7% and 60.8% greater, compared with peak production from the non-grazed plots on the loamy and shallow loamy ecological sites, respectively (Figures 3 and 4).

Above-ground cumulative production on the moderate -use subpasture was 26.7% and 29.7% greater in 2019 and 20.1% and 30.1% greater in 2020, compared with peak production from the non-grazed plots on the loamy and shallow loamy ecological sites, respectively (Figures 5 and 6).

We achieved our targeted degree of disappearance for all years on the full and moderate-use subpasture. The degree of disappearance on the full-use subpasture (targeted use was 40% to 60%) was 39.8% and 49.7% in 2019 and 2020, respectively. The degree of disappearance on the moderate-use subpasture (targeted use was 20% to 40%) was 31.7% and 24.8% in 2019 and 2020, respectively.

We achieved the targeted degree of disappearance on the heavy-use subpasture (targeted use was 60% to 80%) only in 2018 at 64.9%. The degree of disappearance was 57.2% and 56.2% in 2019 and 2020, respectively.

The length of recovery period does not appear to be the driving factor in growth efficiency; instead, the higher degree of disappearance and the uniformity of use across the higher grazing intensity subpastures creates greater regrowth, thus increasing overall growth efficiency.

This study will continue for one more year. A fourth year will allow for comparison of a full cycle to assess growth efficiency and determine if a lag effect (impacts of growth due to previous years' grazing intensity) occurs on herbage production.

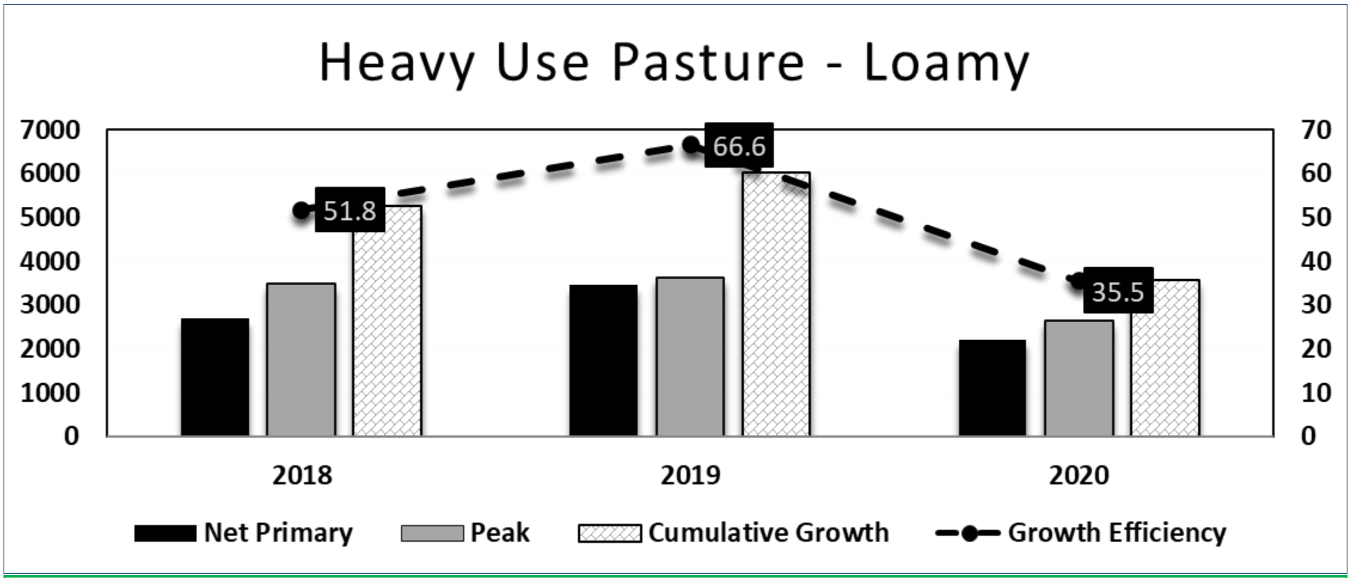

Figure 1. Above-ground net primary, peak and cumulative production on the heavy-use grazing intensity subpasture (pounds/acre, left y-axis) and growth efficiency (percent, right y-axis) from rotational grazing on the loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2018 to 2020.

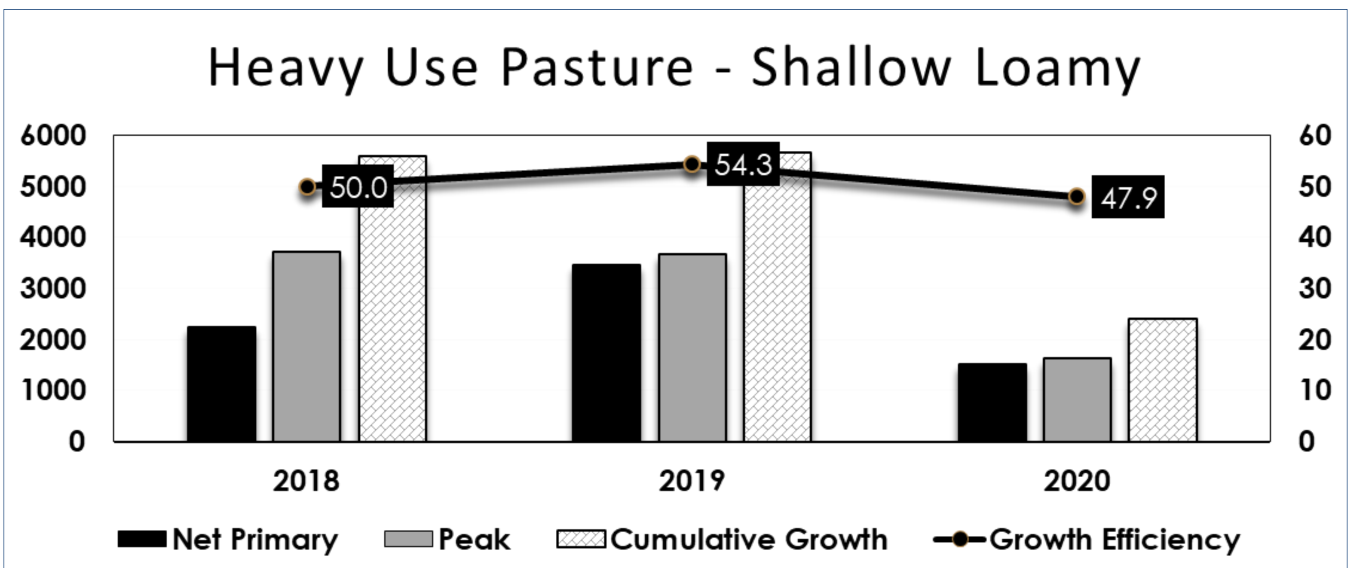

Figure 2. Above-ground net primary, peak and cumulative production on the heavy-use grazing intensity subpasture (pounds/acre, left y-axis) and growth efficiency (percent, right y-axis) from rotational grazing on the shallow loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2018 to 2020.

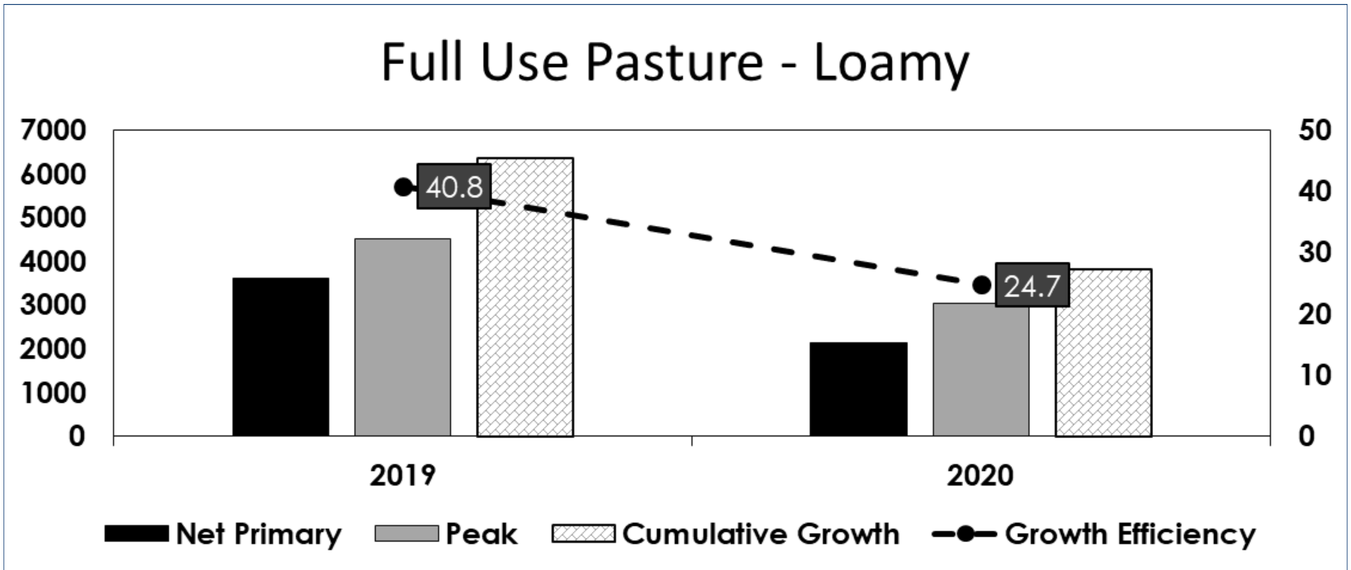

Figure 3. Above-ground net primary, peak and cumulative production on the full-use grazing intensity subpasture (pounds/acre, left y-axis) and growth efficiency (percent, right y-axis) from rotational grazing on the loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2019 to 2020.

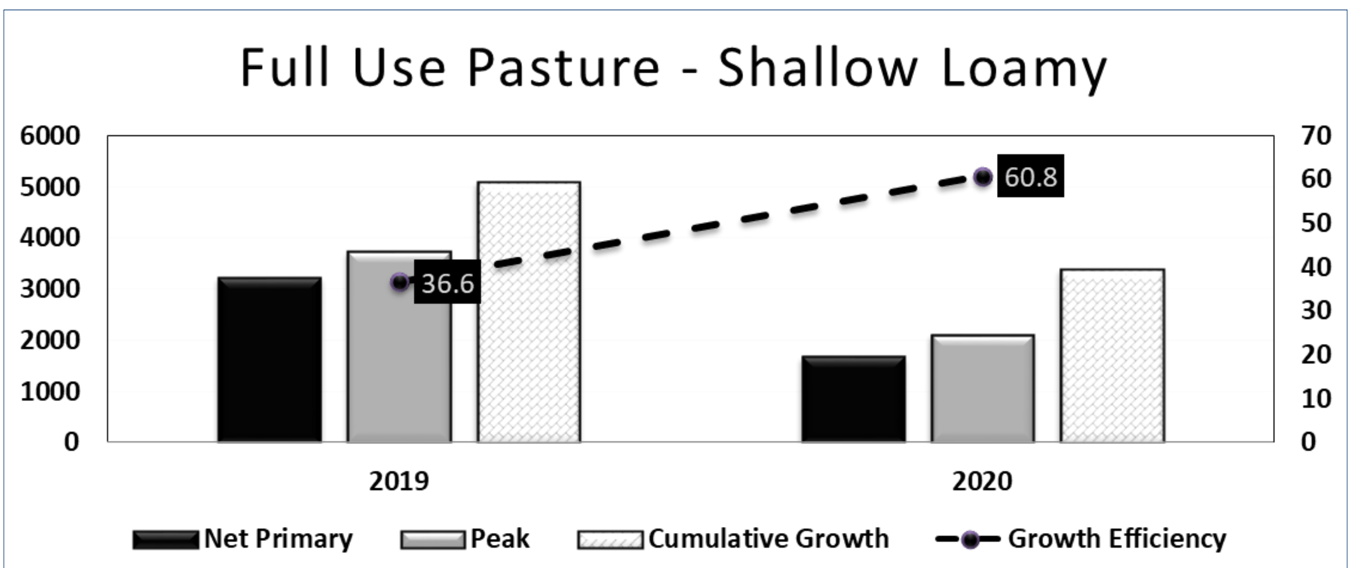

Figure 4. Above-ground net primary, peak and cumulative production on the full-use grazing intensity subpasture (pounds/acre, left y-axis) and growth efficiency (percent, right y-axis) from rotational grazing on the shallow loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2019 to 2020.

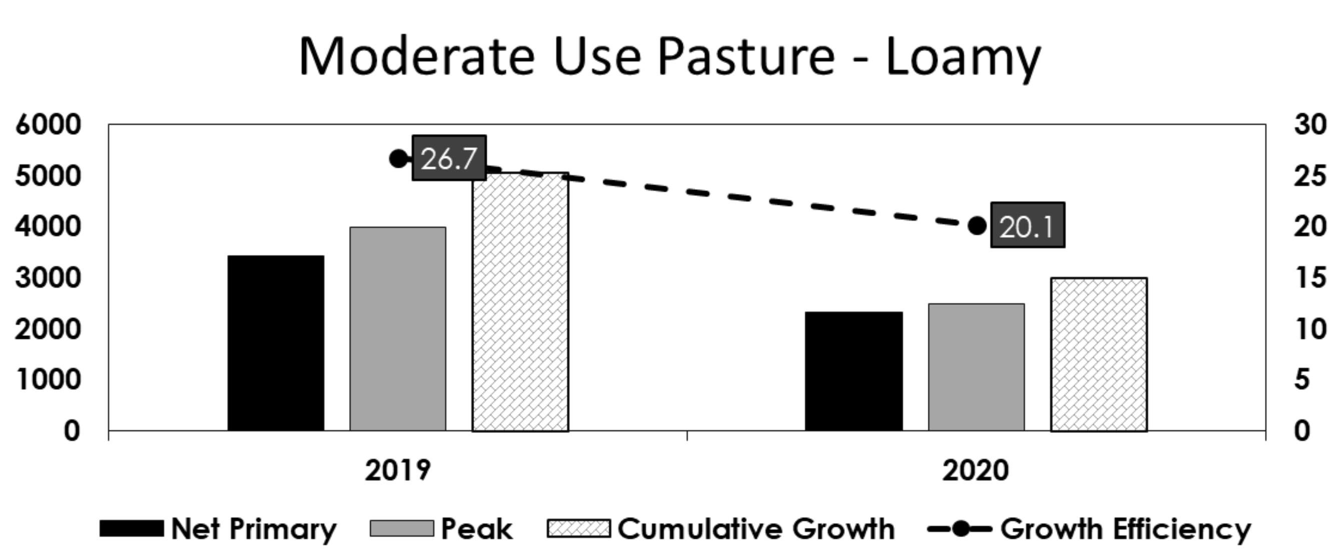

Figure 5. Above-ground net primary, peak and cumulative production on the moderate-use grazing intensity subpasture (pounds/acre, left y-axis) and growth efficiency (percent, right y-axis) from rotational grazing on the loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2019 to 2020.

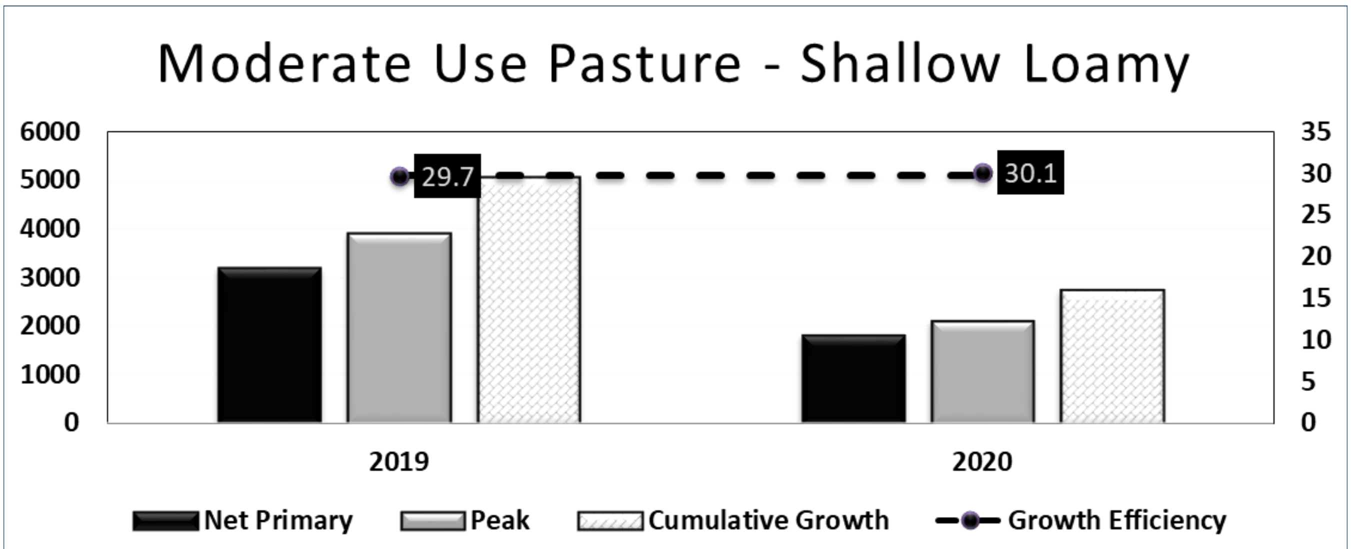

Figure 6. Above-ground net primary, peak and cumulative production on the moderate-use grazing intensity subpasture (pounds/acre, left y-axis) and growth efficiency (percent, right y-axis) from rotational grazing on the shallow loamy ecological site of the modified twice-over rest-rotation grazing treatment at the Central Grasslands Research Extension Center in 2019 to 2020.

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