Comodity production increased with mixed-species grazing and pyric herbivory

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Abstract

Woody plant encroachment (WPE) is a global problem to which browsing herbivory and pyric herbivory are potential sustainable solutions. This study aimed to compare the efficacy of goat browsing and prescribed fire to mitigate WPE on rangelands in different seral states. The effect of browsing and fire in a 2 x 2 factorial design was investigated on rangelands in different seral states, namely woodland, savanna, and grassland. The different seral states were created by mechanically removing woody plants on 2 ha areas to a canopy cover of about 20% (savanna), 5% (grassland), or no removal (woodland). Three 2 ha areas, one in each seral state, were planned to be burned annually, but we were only able to burn in two years and those burns were not effective. Weaned calves were planned to graze for 10 months at a light-moderate stocking rate of 16 ha/AUY. However, because of drought, the average stocking rate was 28 ha/AUY. Angora wether goats grazed for 6 months at an average stocking rate of 20 ha/AUY resulting in a 230% higher stocking rate on multispecies compared to single species grazed pastures. Calf average daily gain (ADG) was higher (P=0.04) on the single species treatment than the mixed species grazing (0.46 vs. 0.54 kg/day, respectively). Because lighter calves have higher market value the economic difference was less than the difference in ADG. Over the three-year study Angora fleece weight averaged 2.4 kg/hd. The value of fleece production on mixed-species grazed pastures was USD 31.60/ha, resulting in a total value of production of USD 61.44/ha compared to USD 32.26 USD/ha on single species grazed pastures. The increased stocking rate due to mixed species grazing on this study was greater than reported in other studies co-grazing goats and cattle.

Introduction

Before the advent of mechanized agriculture, grasslands and savannas accounted for nearly 40% of the earth's surface; today, the remaining intact grasslands and savannas cover only a little over 20%. Rangelands are hotspots of wildlife biodiversity, large repositories of soil carbon, and source areas for clean and abundant water. In addition, they support most of the world's livestock production and are critical for pastoral societies as well as advanced commercial animal production. Despite their importance, grassland biomes are imperiled worldwide. As many as half of them have been converted to croplands or altered by afforestation. The remaining grassland biomes are being degraded by other factors, including invasive species and woody plant encroachment (WPE). The proliferation of trees and shrubs on rangelands is one of the most striking land-cover changes of the last 100–200 years. Since the 1940s, the range management community has aggressively worked to reverse woody proliferation, relying heavily on mechanical and chemical brush control, with the primary goal of increasing forage production for livestock. Enormous amounts of money, effort, and time have

been spent on reversing WPE, but the results have generally been short-lived. Emerging research has identified some management strategies that are extremely promising, not only for maintaining livestock production across the Great Plains but even for increasing it. Examples include pyric herbivory and mixed-species grazing. Pyric herbivory can facilitate the use of prescribed fire by eliminating the need to rest pastures before and after the burn while simultaneously enhancing forage quality and increasing heterogeneity. Mixed species grazing by adding a browsing herbivore helps control woody species and increases animal production.

The objective of this research was to investigate the effect of mixed species grazing and pyric herbivory on WPE and their effect on livestock commodity production.

Methods

The experimental design is a 2 x 2 factorial of with or without pyric herbivory and mixed species grazing with goats. These treatments were conducted on four 48 ha pastures. In addition to the WPE management treatments, woody plant thinning treatments were done before implementing these treatments (Fig. 1). Woody plants were thinned to three levels of canopy cover removal, namely: control (woodland, i.e., no bush removal); savanna (woody plant removal to approximately 20% canopy cover); and grassland (woody plant removal to approximately 5% woody plant cover). These levels of brush control correspond to an Oak/Juniper Woodland Community, Midgrass/Oak/Mixed Brush Savannah, and Historical Climax Plant Community, respectively, in the NRCS Ecological Site Description (ESD) for Low Stony Hill (Site ID: R081BY337TX) the predominant ESD on the study site. Each thinning treatment was done on eight 2 ha blocks in a stratified random manner based on the two soil types present. The thinning treatments aimed to estimate the effect of different initial stages of WPE on the effectiveness of WPE management treatments.

Weaned calves were grazed on all four pastures shortly after weaning in October at a light moderate stocking rate of about 16 ha/Animal Unit Year (AUY), where an AU = 454 kg. Calf stocking rate was kept variable to achieve about a 40% utilization of key species and to try and maintain adequate fine fuel for the prescribed fire treatments. Freshly shorn Angora wether goats browsed from October through March, ie. spring shearing. Goats were planned to be stocked to achieve about a 90% increase in stocking rate compared to cattle only pastures. Animals were weighted on and off pasture, and mohair weighed at spring shearing. Grazing years spanned two calendar years and are referred to by the year when grazing ended.

Randomly selected 2 ha polygons in each of the three woody plant thinning treatments on the two pastures in the pyric herbivory treatment were planned to be burned every year. However, because of drought conditions and lack of fine fuels prescribed fires were only conducted in January 2022 and March 2024.

Because prescribed fires for the pyric herbivory treatment were not conducted as planned and were ineffective when conducted, calf weight gains were analysed only for the effect of grazing treatment and year with analysis of variance. The value of calf weight gain was calculated using local market reports to determine the difference between the values of similar size and class of calves at weaning and their value when removed from the pasture. The value of goat production was calculated from fleece weight and the price of mohair at local markets for each year less the cost of shearing (USD 5.00/hd).

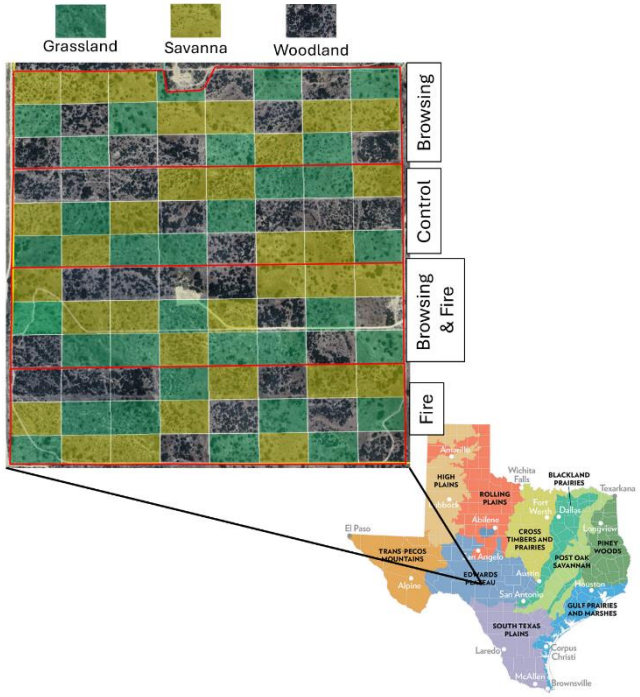

Figure 1. Study area showing 49 ha treatment pastures outlined in red and stratified and randomly distributed 2 ha areas cleared to 5% 20% or uncleared representing grassland, savanna, and woodland, respectively.

Results

During this study, precipitation was 70% of the average, and the calf stocking rate was adjusted to compensate for the deficiency in precipitation (Table 1). The adjustment in cattle stocking rate was done by removing animals sooner than planned. Cattle grazed for the planned duration in only one of the four years of the study and were not grazed in 2023 because of drought (61% of average precipitation). In contrast, goats grazed every year for the planned duration, but they were lighter than expected, resulting in a slightly lower stocking rate. Average stocking rates were over twice as high on the mix-species (12.2 ha/AUY) compared to the single species (28.5 ha/AUY) grazed pastures for the 3 years cattle grazed.

Table 1. Planned and actual stocking rates for during the study period. Years refer to the year grazing ended, and actual grazing spanned two calendar years, beginning in the fall and terminating in spring or summer.

	Planned	2021	2022	2023	2024
Precipitation (mm)	631	452	437	386	506
Calves					
Number	5	4	5	0	5
Body Wt. (kg)	328	265	320	-	320
Day on	Oct 1	Sep 23	Sep 19	-	Nov 1
No. Days on	300	189	302	-	182
ha/AUY	16	40	17	-	28
Goats					
Number	40	40	40	40	40
Body Wt. (kg)	63	43	50	50	51
Day on	Sep 15	Sep 23	Sep 30	Oct 27	Sep 14
No. Days on	182	190	181	166	179
ha/AUY	17	15	22	24	22

There were no grazing treatment x year interactions (P>0.21) for cattle performance metrics. As expected, the average daily gain (ADG) and gain/hd of calves in the single species grazing treatment were greater (P=0.09 and 0.04, respectively) than in the mixed species grazing treatment. The value of the weight gain on the single species treatment was also greater but not significantly. The value of the mohair produced doubled the per ha value of livestock products on the mixed species grazing treatment. The yearly differences in cattle weight gain reflected differences in precipitation.

Table 2. Effect of grazing treatment (single-species vs. mixed-species) and year on livestock production.

	Grazing Treatment			Year			
	Single	Mixed	P-value	2021	2022	2024	P-value
Average daily gain (kg)	0.54	0.46	0.09	0.45[a]	0.40[a]	0.65[b]	<0.01
Gain (kg/hd)	115	98	0.04	85	118	118	0.07
Value (USD/ha)	32.26	29.84	0.12	11.11[a]	35.24[b]	46.80[c]	<0.01
Mohair (kg)		2.4					
Value (USD/ha)		31.60					

Discussion

The two important results of this study were the small difference in cattle weight gain between mixed and single species grazed pastures, given that the stocking rate on mixed species grazed pasture was over twice as high as the single species grazed pasture, and the difficulty of conducting patch burn grazing in areas where annual precipitation is less than 650 mm. Cattle on the single species grazing treatment gained 17% more per head than cattle on the mixed species treatment. The increased stocking rate on the mixed species grazed pastures was much greater than previously reported in other studies. A general recommendation is that 2 breeding goats can be added for each cow without decreasing the stocking rate (Merkle et al. 2014). Animut (2008) calculated a theoretical increase in stocking rate of 60% by adding goats to single species cattle grazing. On an animal unit (AU) basis, those recommendations are equivalent to about 0.3 – 0.6 goat AU/cow AU; our replacement rate was 1.2 goat AU/cow AU or two - four times higher. The season of grazing was primarily responsible for the higher carrying capacity of goats in this study. Goats were grazed in the dormant season because this is the season when their potential impact on juniper encroachment is highest (Taylor 2008) and when their consumption of juniper is highest (Walker et al. 2013). Juniper is not a limiting forage on these rangelands and dormant season grazing minimizes diet overlap with cattle and thus minimizes the effect of the high stocking rate on cattle performance.

Per ha income from mohair production on the mixed species treatment was almost as much as the value of the gain on calves on the single species grazing treatment. This is a result of several factors: on an AUE basis, there were more goats than cattle and the high value of mohair that averaged about $3.80 USD/kg. Angora wether goats were used for this study because they require minimal management and are predator resistant. This makes them an easy class of livestock to incorporate into a cattle operation.

The lack of adequate fine fuel to conduct the planned prescribed burns and the fact that when the burns were conducted the continuity of fine fuel was insufficient to carry fires across the burn unit was a result of insufficient precipitation and soil disturbances caused by the mechanical removal of woody plants. Deferment for several years is recommended on rangelands in fair to poor condition to accumulate adequate fuel for an effective burn (Hanselka 2009). The inability to meet planned burning objectives indicates that patch burn grazing will be difficult to accomplish in areas with less than 650 mm of annual precipitation, unless pastures are in excellent condition.

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All experimental protocols adhered to guidelines for the ethical and humane use of animals for research according to the Guide for the Care and Use of Agricultural Animals in Research and Teaching (FASS, 2010) and were approved by the Texas A&M AgriLife Institutional Animal Care and Use Committee (AUP 2022-008A).

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