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Effect of multi-species grazing on leafy spurge infested rangeland using twice-over rotation and seasonlong grazing treatments (A five-year summary)

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Introduction

Multi-species grazing, the concurrent use of rangeland by more than one kind of animal, has been advocated to maximize animal production on native rangeland (Merrill and Miller 1961). It is an important concept in rangeland management because rangelands usually consist of one or more classes of vegetation (Merrill *et al.* 1966). However, no published reports have documented the potential use of sheep and cattle in a multi-species grazing approach to improve graminoid species use, increase plant species richness and diversity, and to control leafy spurge on leafy spurge infested rangeland.

The objectives of this study were to: 1) determine effects of multi-species grazing using twice-over rotation grazing system (TOR) and seasonlong grazing treatments (SL) in leafy spurge control and changes in plant species diversity 2) evaluate the degree of disappearance of herbage and livestock performance on TOR and SL using a multi-species grazing program.

Study area

The research was conducted on two separate tracts of land in Morton County. The first tract was Sections 31 and 32, T139N, R81W, in south central North Dakota, approximately two miles southwest of Mandan. This tract consisted of 603 acres of native rangeland owned by the North Dakota State Correctional Center. The second tract was on the north half of Section 9, T138N, R81W on 237 acres of native rangeland operated by

the Northern Great Plains Research Laboratory, approximately three miles south of Mandan. Both tracts are found in the Missouri Slope Prairie Region and associated with the Heart River Watershed drainage. Vegetation in this region is typical of northern mixed grass prairie (Barker and Whitman 1989) and classified as a wheatgrass-grama-needle grass (*Agropyron*, *Bouteloua*, *Stipa*) plant community (Shiflet 1994). Leafy spurge infestations were mapped before the study and estimated to cover 30 percent of each tract of rangeland.

The TOR consisted of four pastures grazed from 15 May to 1 October by one heard of cow/calf pairs and mature dry ewes. A total of 96 animal units of cattle (85 - 1200 lb. cows with calves) and 33 animal units of sheep (200-135 lb. mature white-face ewes without lambs) or a total 532 AUMs grazed the TOR treatment in 1996 and 1997. Cattle animal units were reduced to 85 animal units of cattle (76 - 1200 lb. cows with calves) in 1998; however, sheep animal units remained the same and a total 491 AUMs grazed the TOR in 1998. The overall stocking rate was 0.88 AUMs/acre in 1996, 1997, 1999, and 2000; and 0.82 AUMs/acre in 1998 on the TOR treatment. Stocking rates were decreased due to below average winter snow cover and rain fall in the spring 1998.

The SL treatment was grazed moderately light in 1996 due to lack of range evaluation data and unknown carrying capacities. Twenty-seven animal units of cattle (35-700 lb. Yearling steers) and 8 animal units of sheep (48 - 135 lb. mature white-face ewes without lambs) or a total 144 AUMs grazed the SL treatment in 1996. The overall stocking rate was 0.68 AUMs/acre in 1996 on the SL treatment. The SL treatment was grazed by yearling steers and mature ewes and stocked with 37 animal units of cattle (49 - 705 lb. yearling steers) and 13 animal units of sheep (78 - 135 lb. mature white-face ewes without lambs) or a total 207 AUMs grazed in 1997 and 1998. The overall stocking rate was 0.88 AUMs/acre in 1997, 1998, 1999, and 2000 on the SL treatment.

Sheep were placed on pasture approximately 15 May each year when leafy spurge was ready for grazing and cattle placed on pasture 1 June when native cool season grass species reach grazing readiness (3-4 leaf stage). Livestock species were removed from the treatments when 50 to 60 percent degree of graminoid disappearance was reached or 1 October. During all three years livestock grazed until 1 October.

Methods

Objective 1

Leafy spurge density was counted in six 32 ft by 16 ft exclosures. Three exclosures were systematically placed in each of the TOR and SL treatments. Each 32 ft by 16 ft exclosure was subdivided in two 16 ft by 16 ft plots with one plot randomly assigned a grazed treatment (TOR or SL) and second plot an ungrazed treatment (NU). A 2.5 ft buffer was placed along the inside border of each grazed and ungrazed plot to prevent an edge effect. Each plot was further stratified into 12 inch² (0.1 m²) quadrats and each quadrat assigned a number. Ten 12 inch² quadrats were randomly selected in each treatment for leafy spurge density counts. Leafy spurge densities were collected in the first week of June throughout the duration of the study.

Objective 2

Forage production and degree of disappearance for leafy spurge, graminoid, shrubs, and other forbs were determined using a pair-plot clipping technique (Milner and Hughes 1968). Eight cages were dispersed in each of the four pastures of the TOR. Four of the cages were systematically placed in leafy spurge infested sites and four in non-infested sites. Twelve cages were systematically placed in the SL, six cages placed on leafy spurge infested sites and six cages on non-infested sites. Two plots were clipped from each cage using a 24 inch² (0.25 m²) frames.

Livestock performance and production were determined for both cattle and sheep and expressed as average daily gain. Weights were taken when animals were allocated to and removed from each treatment.

Data analysis

Treatment and year effects for leafy spurge stem density, species richness, forb and shrub density, herbage production, degree of use, and livestock performances were analyzed using a general linear model (GLM) (SPSS 1999). A mean separation was performed using Tukey's Honest Significant Difference when significant ($P \leq 0.05$) differences were found. The Shannon Wiener Index was used to calculate species diversity indices for both leafy spurge infested and non leafy spurge infested range sites. Treatment and year effects of species diversity were analyzed using a non-parametric test (Kruskal-Wallis Test) (SPSS 1999).

Results and discussion

Leafy spurge stem densities were significantly reduced ($P \leq 0.05$) on the SL treatment after 3 grazing seasons and after 4 grazing seasons on the TOR treatment. Leafy spurge stem density was reduced on the SL from 14.4 ± 1.9 stems/0.12 inch² to 5.7 ± 0.6 stems/0.12 inch² in three years of treatment, a 60.4% reduction in leafy spurge stem density. Twice-over rotation grazing treatment reduced ($P \leq 0.05$) leafy spurge density by 31.8% in four grazing seasons, 13.2 ± 1.5 stems/0.12 inch² to 9.0 ± 1.3 stems/0.12 inch² (Table 1). These results followed similar trends found by Lym *et al.* (1997) comparing multi-species grazing with cattle and angora goats. They reported SL grazing reduced leafy spurge stem density faster than TOR grazing. Results of this study would support Lym *et al.* (1997) in that SL grazing using a multi-species approach would reduce leafy spurge stem density faster than TOR grazing. Long term, however, the TOR grazing treatment would provide comparable control to the SL treatment and be beneficial to the plant community.

Forb and shrub densities results showed that there were significant changes ($P \leq 0.05$) in density/0.24 inch² in both the SL and TOR grazing treatments (Table 2). Results showed that forb and shrub densities increased ($P \leq 0.05$) on the shallow native range sites in the TOR grazing treatment, from 1996 to 2000. The SL on the other hand saw a sig-

nificant decrease ($P \leq 0.05$) after one year of grazing. Forb and shrub density was also higher ($P \leq 0.05$) on the SL shallow native range sites than the TOR shallow native range sites. By the third grazing season, however, the TOR shallow native range sites were significantly higher ($P \leq 0.05$) than the SL native range sites (Table 2). Leafy spurge infested range sites were generally lower ($P \leq 0.05$) than native range sites for both the SL and TOR grazing treatments throughout four grazing seasons. Results also suggested that there were no significant changes ($P \leq 0.05$) on leafy spurge infested sites through four grazing seasons on both the grazing treatments (Table 2).

Species diversity was significantly higher ($P \leq 0.05$) on native range sites than leafy spurge infested range sites on the seasonlong treatment, except the silty sites in 1998 (Table 3). There were no differences ($P > 0.05$) between native and leafy spurge infested range sites on these silty range sites. The TOR grazing treatment, however, results showed that there were no differences ($P > 0.05$) between native and leafy spurge infested range sites after four grazing seasons, except the silty sites in 1996 where the native sites were higher ($P \leq 0.05$) than leafy spurge infested sites (Table 3). Results also indicated that the SL native shallow range sites were significantly higher ($P \leq 0.05$) in species diversity than the TOR native shallow range sites (Table 3). There were no differences ($P > 0.05$) between the SL and TOR grazing treatments on the native silty range sites.

Table 1. Leafy spurge stem densities on the seasonlong and twice-over rotation grazing treatments in 1996, 1997, 1998, 1999 and 2000 (standard errors in parentheses).

	Seasonlong	Twice-Over Rotation
	# of Leafy Spurge Stems /12 inch ²	
1996	14.4 (1.9) ^a	13.2 (1.5) ^a
1997	12.5 (1.0) ^a	15.9 (1.4) ^a
% change 1996 to 1997	-13.2	+20.5
1998	11.5 (1.5) ^a	12.8 (1.1) ^{ac}
% change 1996 to 1998	-20.1	-3.0
1999	5.7 (0.6) ^b	13.4 (1.4) ^a
% change 1996 to 1999	-60.4	+1.0
2000	1.1 (0.3) ^b	9.0 (1.3) ^c
% change 1996 to 2000	-92.3	-31.8

^aYears and treatments with the same letter within treatments are not significantly different ($P > 0.05$).

Degree of leafy spurge disappearance on both treatments was similar throughout the four grazing seasons 1996, 1997, 1998, and 1999. The degree of leafy spurge disappearance varied from 41% to 89% over four grazing seasons in both treatments. Grass and grass-like species degree of use within leafy spurge infested communities increased on

both treatments after the first grazing season. Grass and grass-like plant species disappearance in leafy spurge infested sites was 1% on the SL and 2% on the TOR treatment, however, by the fourth grazing season, grass and grass-like degree of disappearance increased to 30% on the SL and 20% on the TOR on leafy spurge infested communities. In the third and fourth year, degree of grass and grass-like species disappearance showed a slight increase again on leafy spurge communities compared with 1996 and 1997 (Table 5).

Cow average daily gains (ADG) were higher ($P < 0.05$) on the TOR treatment in 1997 and 2000 than 1996, 1998, and 1999. Results also showed that cow ADG was higher ($P \leq 0.05$) in 2000 than 1997 (Table 6). Calf ADG was similar ($P > 0.05$) throughout three grazing seasons, however, ADG significantly increased ($P \leq 0.05$) during the fourth grazing season (Table 6). Steer ADG was higher ($P \leq 0.05$) in 1996 and 1999 than 1997 and 1998 grazing seasons (Table 6).

Ewe ADG on the TOR treatment was lower ($P < 0.05$) in 1997, 1998, and 1999 compared with 1996 and 2000, dropping from 0.32 lb/day in 1996 to 0.25 lb/day and 0.26 lb/day in 1997 and 1998, respectively (Table 6). Seasonlong ewe ADG increased ($P < 0.05$) from 1996 to 1997; however, there was a significant decrease ($P < 0.05$) in ewe ADG from 1997 to 1998, with 1996 and 1998 not different ($P > 0.05$). Ewe performance results also showed that ewe ADG was higher ($P < 0.05$) on the TOR in 1996, 1997, 1999, and 2000 than the SL, with no treatment differences ($P > 0.05$) occurring in 1998 (Table 6).

Table 2. Forb and shrub density on the twice-over rotation and seasonlong treatments for 1996, 1997, 1998, 1999, and 2000 (standard errors in parentheses).

Treatments & Sites	1996	1997	1998	1999	2000
	Density/24 inch ² quadrat				
Twice-Over					
Native Shallow	8.9 (0.9) ^{ax}	—	4.4 (0.5) ^{ax}	25.9 (2.4) ^{cx}	20.2 (1.8) ^{bx}
Leafy Spurge Shallow	1.1 (0.3) ^{ay}	0.8 (0.2) ^{ay}	0.6 (0.2) ^{ax}	2.0 (0.6) ^{ay}	3.4 (1.1) ^{ay}
Native Silty	8.0 (0.9) ^{abx}	—	5.5 (0.7) ^{ax}	11.4 (1.6) ^{bx}	4.1 (0.6) ^{ax}
Leafy Spurge Silty	0.8 (0.2) ^{abx}	1.2 (0.8) ^{ay}	0.8 (0.2) ^{ax}	1.3 (0.3) ^{ay}	0.8 (0.3) ^{ax}
Seasonlong					
Native Shallow	22.7 (2.1) ^{cz}	—	7.8 (0.8) ^{abx}	13.0 (1.1) ^{bz}	7.2 (0.6) ^{az}
Leafy Spurge Shallow	0.1 (0.1) ^{ay}	0.2 (0.1) ^{ay}	0.2 (0.1) ^{ay}	0.6 (0.2) ^{ay}	0.3 (0.1) ^{ay}
Native Silty	6.9 (0.9) ^{ax}	—	6.2 (0.5) ^{ax}	6.6 (0.6) ^{ax}	7.3 (0.6) ^{ax}
Leafy Spurge Silty	0.0 (0.0) ^{ay}	0.0 (0.0) ^{ay}	0.3 (0.2) ^{ax}	0.3 (0.1) ^{ax}	1.0 (0.4) ^{ax}

¹Years with the same letter within each treatment are not significantly different ($P > 0.05$) (a, b, and c).

²Treatments with the same letter within each year are not significantly different ($P > 0.05$) (x, y, and z).

Table 3. Shannon Weiner diversity index on the twice-over rotation and seasonlong treatments for 1996, 1997, 1998, 1999, and 2000 (standard errors in parentheses).

Treatments & Sites	1996	1997	1998	1999	2000
Species Diversity Index					
Twice-Over					
Native Shallow	2.55 (0.13) ^{ax}	—	2.36 (0.22) ^{ax}	2.36 (0.08) ^{ax}	2.04 (0.10) ^{ax}
Leafy Spurge Shallow	2.25 (0.18) ^{ax}	2.09 (0.15) ^{ay}	2.19 (0.17) ^{ax}	2.39 (0.26) ^{ax}	2.15 (0.40) ^{ax}
Native Silty	2.62 (0.09) ^{ax}		2.44 (0.08) ^{ax}	2.34 (0.21) ^{abx}	2.07 (0.09) ^{abx}
Leafy Spurge Silty	2.19 (0.06) ^{ay}	2.09 (0.04) ^{ay}	2.39 (0.24) ^{ax}	2.31 (0.29) ^{ax}	2.28 (0.17) ^{ax}
Seasonlong					
Native Shallow	2.98 (0.11) ^{abx}	—	3.01 (0.09) ^{abz}	2.65 (0.25) ^{ax}	3.06 (0.10) ^{bz}
Leafy Spurge Shallow	2.12 (0.02) ^{ay}	1.99 (0.17) ^{ay}	1.94 (0.11) ^{ay}	2.14 (0.24) ^{ay}	2.04 (0.39) ^{ay}
Native Silty	2.69 (0.13) ^{abx}	—	2.52 (0.09) ^{ax}	2.69 (0.09) ^{abx}	2.83 (0.08) ^{bz}
Leafy Spurge Silty	2.15 (0.01) ^{ay}	2.04 (0.13) ^{ay}	2.22 (0.09) ^{ax}	2.15 (0.06) ^{ay}	2.00 (0.02) ^{ay}

Years with the same letter within each treatment are not significantly different ($P>0.05$) (a, b, and c).

Treatments with the same letter within each year are not significantly different ($P>0.05$) (x, y, and z).

Table 4. Degree of disappearance on native range sites on the twice-over rotation (TOR) and seasonlong (SL) grazing treatments, through five grazing seasons.

	TOR					SL				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
% Disappearance										
Grass and Grass-like	34	37	24	18	38	21	32	37	43	34
Forbs	+2	51	36	69	42	+34	71	32	61	63
Shrubs	100	0	0	0	0	55	100	20	0	0

Table 5. Degree of disappearance on leafy spurge infested range sites on the twice-over rotation (TOR) and seasonlong (SL) grazing treatments, through five grazing seasons.

	TOR					SL				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
% Disappearance										
Grass and Grass-like	2	20	27	25	11	1	33	40	39	47
Forbs	0	89	83	22	1	0	0	0	85	0
Shrubs	0	0	0	0	0	0	100	0	0	0
Leafy Spurge	41	61	62	73	41	47	47	46	89	100

Table 6. Livestock average daily gains (standard errors in parentheses) for individual classes of livestock on treatments: twice-over rotation (TOR) and seasonlong (SL) for 1996, 1997, 1998, 1999, and 2000 (standard errors in parentheses).

Treatment & Livestock Class ¹	1996 ²	1997 ²	1998 ²	1999 ²	2000 ²
	————— lb/day —————				
TOR					
Cow	0.78 (0.05) ^a	1.00 (0.05) ^b	0.01 (0.04) ^c	0.67 (0.05) ^a	1.39 (0.05) ^d
Calf	2.33 (0.03) ^a	2.32 (0.03) ^a	2.42 (0.03) ^a	2.64 (0.03) ^b	2.86 (0.02) ^b
Ewe	0.32 (0.01) ^{ax}	0.25 (0.01) ^{bx}	0.26 (0.01) ^{bx}	0.24 (0.01) ^{bx}	0.30 (0.004) ^{ax}
SL					
Steer	1.99 (0.04) ^{ac}	1.84 (0.03) ^a	1.54 (0.04) ^b	2.09 (0.04) ^c	1.91 (0.22) ^a
Ewe	0.23 (0.03) ^{aby}	0.28 (0.03) ^{by}	0.22 (0.01) ^{ax}	0.17 (0.01) ^{cy}	0.19 (0.006) ^{acy}

¹ Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, c, and d).

² Sheep (ewe) treatments with the same letter within each year are not significantly different (P>0.05) (x, y, and z).

Conclusion

Multi-species grazing with cattle and sheep in a seasonlong grazing treatment will reduce leafy spurge quicker than a twice-over rotation grazing treatment. The trend of this study, however, would show that in time the twice-over rotation would provide similar control than the seasonlong in a long term management plan. The continuation of this project will allow use to detect which treatment will increase plant species diversity on leafy spurge infested sites. At this time it is too soon to make any conclusion on species diversity. Livestock performance results showed that the twice-over rotation has provided greater average daily gains than the seasonlong for the ewes, however, this may be related to the amount of leafy spurge remaining in the twice-over rotation treatment. Leafy spurge stem counts on the twice-over are still much higher than the seasonlong, which would suggest that the ewes on the twice-over are receiving a higher quality diet than the seasonlong throughout the growing season with the presence of leafy spurge. Livestock results have also shown that the twice-over rotation has increased calf average daily gains over five grazing seasons.

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