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Effects of multi-species grazing and single species grazing on leafy spurge infested rangeland (A five-year summary)

J. D. DAHL[1], K. K. SEDIVEC[2], T. C. FALLER[1], D. STECHER[1], J. F. KARN[3], P. E. NYREN[4], and L. SAMUEL[2]

[1]NDSU Hettinger Research Extension Center, Hettinger; [2]Animal and Range Sciences Department, North Dakota State University, Fargo, ND; [3]Northern Great Plains Agricultural Research Center, Mandan, ND; [4]Central Grasslands Research Center, Streeter, ND.

Introduction

Multi-species grazing is an important idea in rangeland management because rangelands usually consist of one or more classes of vegetation (Merrill *et al*. 1966). By using more than one livestock species on a given rangeland containing various vegetative communities provides the potential of increasing red meat production, species diversity, vegetative production, and revenue for a given ranching operation, with proper management plans. Although multi-species grazing provides the above benefits, the introduction of leafy spurge and its consistency of infesting grasslands in the midwest exploits the importance of using a multi-species grazing approach. Research has shown that sheep or goats will reduce leafy spurge stem densities and increase grass and grass-like disappearance, and there are significant benefits in using multi-species grazing to manage leafy spurge infested rangelands (Prosser 1995).

The objectives of this study were to test the effects of multi-species and single species grazing treatments using cattle and sheep on: 1) differences in leafy spurge control, plant species richness and density, plant species diversity, 2) evaluate differences in utilization levels by plant type and herbage production, and 3) evaluate differences in livestock weight gain.

Study area

This study was conducted on Section 32, T139N, R81W of Morton County owned by the North Dakota State Correction Center in south central North Dakota, approximately two miles southwest of Mandan, and on the north half of Section 9T138N, R81W of

Morton county on native rangeland operated by the Northern Great Plains Research Laboratory, approximately three miles south of Mandan. The study area was located in the Missouri Slope Prairie region. 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).

Grazing treatments were multi-species and single species grazing on three replicated 20 acre blocks. Replicate one and two were within the North Dakota State Correction Center land and replicate three on the Northern Great Plains Research Laboratory. Each of the replicates were subdivided into 5 acre plots and treated with either a cattle only treatment (CO), sheep only treatment (SO), cattle and sheep treatment (CS) or a non use control (NU). Treatments were randomly selected within each block. The experimental design was a randomized complete block design (RCBD).

Sheep were placed on treatments approximately 15 May and cattle 1 June when native cool season grass species reach grazing readiness (3-4 leaf stage). Livestock species were removed from treatments when 50 to 60 percent degree of grass and grass-like species use or before 15 September.

Each replicated research block had one plot grazed by yearling steers (CO), one grazed by mature ewes (SO), and one grazed by yearling steers and mature ewes (CS). Stocking rates include two yearling steers for the CO from 1996 to 1999; twelve mature ewes in 1996, ten-mature ewes 1997 and 1998, and seven mature ewes in 1999 for the SO; one yearling steer and six mature ewes in 1996 and one yearling steer and five mature ewes for the CS from 1997 to 1999. Stocking rates were about 1.5 AUMs/acre for the CO, SO, and CS treatments. Stocking rates for this trial were designed for 3.5 months of grazing for the steers and 4 months of grazing for the ewes. The flexible stocking rates on the SO and CS in sheep was due the adjustment in leafy spurge control and range condition.

Methods

Leafy spurge stem density counts were obtained by using a permanent 109 yard line transect and counts collected approximately every 5½ yards using a 12 inch^2 quadrat. One transect was systematically placed in each of the four treatments (CO, SO, CS, and NU) for each replicate. Transects were selected based on leafy spurge location within the treatments to assure full length of transect comprised leafy spurge. Leafy spurge densities were monitored over the five years to detect effectiveness of sheep grazing to control. Leafy spurge densities will be collected annually, around the end of May, for the duration of the study.

Leafy spurge vigor was monitored in 2000 by collecting the height of the plant and growth stage of the plant on 1 May, 22 May, and 15 June. Twenty leafy spurge plants were randomly selected from each treatment. Leafy spurge plants were measured in inches and the growth stages were broke down into, as follows: seedling, vegetative, formation of bracts, flowering, and formation of seed pods. Vigor of leafy spurge will be collected throughout the duration of the study to detect any changes within and among treatments.

Forb and shrub species diversity and densities were determined using a 24 inch^2 quadrat. Nested within the 24 inch^2 quadrat was a 12 inch^2 quadrat used to determine graminoid species diversity. Data was collected from 109 yard transects with readings conducted approximately every 5½ yards. Data was collected on all treatments and replicate from the leafy spurge transect developed to monitor leafy spurge stem density counts. One native (non-infested) 109 yard transect was located within each replicated treatment to monitor species diversity and density changes that may naturally occur due to treatment. Readings were collected from the native transects annually, except 1997. The leafy spurge transects were monitored annually and will continue to be monitored annually throughout the ten-year trial.

Leafy spurge, graminoid, shrub, and forb herbage production was determined by clipping in late July on the NU treatment when vegetative species reached peak production (Whitman *et al*. 1952). The NU was stratified into 7½ by 7½ yard plot. A 7½ yard buffer's strip was implemented to prevent edge effect. Twenty-five plots were randomly selected and clipped within each NU using a 24 inch^2 quadrat.

Degree of disappearance of leafy spurge, graminoids, forbs, and shrubs were determined for each treatment at the end of the grazing season by stratifying each treatment into 7½ by 7½ yard quadrats in 1996, 1997, 1998, and 1999. Twenty-five quadrats were randomly selected and clipped using 24 inch^2 quadrat on each grazed and non-use treatment to determine the degree of disappearance. The method of determining degree of disappearance was change in 2000 due to the change in herbage production on the grazing treatments. Degree of disappearance was monitored using the pair-plot technique in 2000, two frames within the cage and two out were clipped after the removal of livestock species. Five cages were systematically placed within each grazing treatment (CO, SO, and CS) in leafy spurge infested sites. This method allowed use to monitor the herbage production on the grazing treatments and the degree of disappearance of grass and grass-like species, forbs, shrubs, and leafy spurge.

Livestock performance and production were collected for both cattle and sheep by determining average daily gain and gain per acre, respectively. Both classes of livestock were weighed prior to pasture turn out and monthly to follow performance throughout the grazing season. Final livestock weights were collected at the end of grazing season.

Treatment and year effects for leafy spurge stem density, forb and shrub density, herbage production, degree of disappearance, and livestock performances were analyzed using a general linear model (GLM) (SPSS 1999). A mean separation was performed using Tukey's Honesty 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-infested range sites. Treatment and year effects of species diversity were analyzed using a non-parametric test (Krushal-Wallis Test) (SPSS 1999).

Results and discussion

A significant ($P \leq 0.05$) reduction in leafy spurge stems occurred after one grazing season on the SO treatment and in three grazing seasons on the CS treatment. Leafy spurge was reduced from 10.4 stems/12 inch^2 in 1996 to 0.6 inch^2 stems in 2000, a reduction of

36% after one grazing season and 98% after four on the SO. Leafy spurge stem densities were not affected after two grazing seasons on the CS treatment, however, by the third year the CS treatment had a significant ($P \leq 0.05$) reduction and results showed that a significant ($P \leq 0.05$) change between year three and four. Leafy spurge stems were reduced ($P \leq 0.05$) from 11.6 stems/12 inch^2 in 1996 to 2.1 stems/12 inch^2 in 2000, a reduction of 82% after four grazing seasons. There was no significant ($P > 0.05$) change in leafy spurge stem density on the CO and NU treatments after three years of grazing (Table 1).

Leafy spurge vigor results showed that the growth stage during the three collection periods on the SO and CS treatments never made it past vegetative stage. The average height of the plants on the SO and CS was less than eight inches in height. By the third collection 46.7% and 73.3% of the leafy spurge plants measured were in the formation of seed pods on the NU and CO treatments and the average heights of the plants were more than 19 inches (Table 2).

Leafy spurge and non-infested range sites were significantly ($P \leq 0.05$) different in forb and shrub density on the NU treatment throughout four grazing seasons. Non-infested range sites had a higher ($P \leq 0.05$) forb and shrub density/24 inch^2 than leafy spurge range sites. Results after two grazing seasons showed that there were no differences ($P > 0.05$) between non-infested and leafy spurge range sites on the CO, SO, and CS grazing treatments in forb and shrub densities (Table 3). By the third year of grazing, however, forb and shrub density on treatments CO and SO showed that there was a difference between the non-infested and leafy spurge range sites. Non-infested sites were significantly higher ($P \leq 0.05$) than leafy spurge range sites on both CO and SO treatments. Forb and shrub density results also suggested that after the forth grazing season the only treatment that showed no differences between the non-infested and leafy spurge sites were the CS grazing treatment (Table 3).

Species diversity results showed that there were significant ($P \leq 0.05$) differences between leafy spurge and non-infested range sites in all treatments. In all of the treatments non-infested range sites were higher ($P \leq 0.05$) in species diversity than leafy spurge infested sites. Results also showed that species diversity did not change ($P > 0.05$) after four grazing seasons and there was no treatment or year effect present after the four years of grazing (Table 4).

Herbage production was different ($P \leq 0.05$) between growing seasons in grass and grass-like lb/acre. Results showed that graminoid grass and grass-like lb/acre was lower ($P \leq 0.05$) in 1998 than 1996, 1999 and 2000, however, were similar ($P > 0.05$) to 1997. Leafy spurge production was significantly higher ($P \leq 0.05$) in 2000 than 1998, however, similar to production in 1996, 1997, and 1999. (Table 5).

Leafy spurge degree of disappearance increased on all sheep treatments form 1996 to 2000. The SO treatment went from 76% to 99% leafy spurge disappearance from 1996 to 2000, and the CS treatment went from 62% to 97% from 1996 to 2000. There was an increase ($P \leq 0.05$) in leafy spurge disappearance in the CO treatment with 23% disappearance in 1996 compared with 50% in 1997 and 1998; however, reduced again to 23% in 1999. These results in leafy purge disappearance on the CO treatment would suggest that steers were consuming leafy spurge; however, due to the design and location of watering facilities, the leafy spurge disappearance was more likely due to a trampling effect. As

graminoid disappearance increased on CO treatment, so did leafy spurge disappearance, suggesting more use of the graminoids, more grazing and trampling occurs. Graminoid degree of disappearance was similar (P>0.05) throughout the grazing seasons within and between grazing treatments for all years except 1999, where graminoid disappearance was reduced on the sheep treatments

Steer average daily gain (ADG) was not different (P>0.05) between treatments (CO and CS) after four grazing seasons of the study (Table 6). There was no change (P>0.05) in steer ADG between years on the CO and CS treatment. Ewe ADG was not different (P>0.05) between treatments (SO and CS) for either years of the study. There was a decrease (P≤0.05) in ewe ADG between years 1996 and 1998 on both SO and CS treatments, however, ADG was significantly higher (P≤0.05) in 1999 than the 1998 grazing season (Table 6). These results would suggest multi-species grazing had no negative or positive impact on sheep or cattle performance compared with single species grazing.

Table 1. Leafy spurge stem densities per 12 inch^2 quadrat (standard errors in parentheses) on the cattle only (CO), sheep only (SO), cattle and sheep (CS), and control (NU) treatments for 1996, 1997, 1998, 1999, and 2000.

	CO[2]	SO[2]	CS[2]	NU[2]
	# of Stems/12 inch^2 quadrat			
1996[1]	9.8 (1.2)^{abx}	10.4 (0.9)^{ax}	11.6 (1.0)^{ax}	9.8 (1.1)^{ax}
1997[1]	12.0 (1.2)^{ax}	6.7 (0.7)^{by}	12.3 (1.0)^{ax}	11.4 (1.3)^{ax}
% Change 1996 to 1997	+22	-36	+6	+16
1998[1]	10.8 (1.0)^{ax}	2.5 (0.6)^{cy}	11.6 (1.0)^{ax}	11.1 (1.2)^{ax}
% Change 1996 to 1998	+10	-75	0	+13
1999[1]	11.1 (0.8)^{ax}	0.8 (0.2)^{cy}	6.5 (0.8)^{bz}	10.5 (1.0)^{ax}
% Change 1996 to 1999	+13	-92	-44	+7
2000[1]	6.2 (0.8)^{bx}	0.6 (0.2)^{cy}	2.1 (0.3)^{cy}	8.1 (0.8)^{ax}
% Change 1996 to 2000	-37	-94	-82	-17

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

[2]Treatments with the same letter are not significantly different (P>0.05) (x, y, and z).

Table 2. Growth stage of leafy spurge on treatments non-use (NU), cattle only (CO), sheep only (SO), and cattle and sheep (CS) during the 2000 growing season. The table is broken down by collection data's and summarized by percentage (%) of samples during that collection period occurred in the growth stage and the height of the leafy spurge plant in inches (inch).

	Seedling		Vegetative		Formation of Bracts		Bracts		Flowering		Formation of Seed Pods	
	%	inch	%	inch	%	inch	%	inch	%	inch	%	inch
NU												
5/01/00	–	–	62.5	6.9 (0.3)	37.5	9.2 (0.6)	–	–	–	–	–	–
5/22/00	–	–	48.3	9.9 (0.8)	–	–	16.7	14.8 (0.4)	35	16.7 (0.7)	–	–
6/15/00	–	–	43.3	11.0 (0.7)	–	–	10	15.1 (1.1)	–	–	46.7	19.1 (0.7)
CO												
5/01/00	2.5	3.2 (NA)	52.5	6.5 (0.4)	45	9.1 (0.3)	–	–	–	–	–	–
5/22/00	–	–	60	10.7 (0.7)	–	–	11.7	16.3 (2.1)	28.3	18.4 (1.0)	–	–
6/15/00	–	–	25	14.5 (0.7)	–	–	1.7	18.5 (NA)	–	–	73.3	22.7 (0.5)
SO												
5/01/00	95	2.9 (0.2)	5	4.3 (0.04)	–	–	–	–	–	–	–	–
5/22/00	–	–	100	4.2 (0.2)	–	–	–	–	–	–	–	–
6/15/00	–	–	100	4.1 (0.2)	–	–	–	–	–	–	–	–
CS												
5/01/00	90	2.6 (0.2)	10	4.4 (0.2)	–	–	–	–	–	–	–	–
5/22/00	–	–	100	4.7 (0.2)	–	–	–	–	–	–	–	–
6/15/00	–	–	100	7.1 (0.3)	–	–	–	–	–	–	–	–

Table 3. Forb and shrub species density/24 inch^2 quadrat on the cattle only non-infested (CON), cattle only leafy spurge infested (COS), sheep only non-infested (SON), sheep only leafy spurge infested (SOS), cattle and sheep non-infested (CSN), cattle and sheep leafy spurge infested (CSS), control non-infested (NUN), and control leafy spurge infested (NUS) treatments for 1996, 1997, 1998, 1999, and 2000. (SE in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]
	Density/24 inch^2 quadrat				
CON[2]	6.7 (1.0)^{abxx}	——	4.1 (0.1)^{ax}	7.8 (1.1)^{bxz}	9.5 (1.5)^{bz}
COS[2]	1.8 (0.4)^{ay}	1.5 (0.4)^{ax}	1.3 (0.3)^{ax}	1.0 (0.3)^{ay}	1.1 (0.3)^{ay}
SON[2]	5.8 (1.1)^{axz}	——	2.1 (0.5)^{bx}	7.0 (1.5)^{ax}	6.0 (0.9)^{ax}
SOS[2]	1.1 (0.3)^{ay}	0.5 (0.2)^{ax}	0.8 (0.2)^{ax}	2.2 (0.5)^{ay}	1.7 (0.2)^{ay}
CSN[2]	4.5 (0.4)^{ax}	——	2.3 (0.4)^{ax}	3.0 (0.4)^{ay}	3.5 (0.5)^{ay}
CSS[2]	0.9 (0.2)^{ay}	0.3 (0.1)^{ax}	0.8 (0.3)^{ax}	1.4 (0.4)^{ay}	0.9 (0.4)^{ay}
NUN[2]	7.8 (0.9)^{az}	——	6.9 (0.8)^{ax}	5.8 (0.7)^{az}	6.1 (0.7)^{ax}
NUS[2]	1.1 (0.4)^{ay}	0.9 (0.3)^{ax}	1.0 (0.3)^{ax}	1.9 (0.5)^{ay}	1.6 (0.4)^{ay}

[1]Years with the same letter within each treatment are not significantly different (P>0.05) (a and b).
[2]Treatments with the same letter are not significantly different (P>0.05) (x, y, and z).

Table 4. Shannon Weiner diversity index on the cattle only non-infested (CON), cattle only leafy spurge infested (COS), sheep only non-infested (SON), sheep only leafy spurge infested (SOS), cattle and sheep non-infested (CSN), cattle and sheep leafy spurge infested (CSS), non-use control non-infested (NUN), and non-use control leafy spurge infested (NUS) treatments for 1996, 1997, 1998, 1999, and 2000. (SE in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]
	Species Diversity Index				
CON[2]	2.73 (0.17)^{ax}	——	2.60 (0.10)^{ax}	2.60 (0.05)^{ax}	2.65 (0.14)^{ax}
COS[2]	2.30 (0.07)^{ay}	2.23 (0.26)^{ay}	2.12 (0.13)^{ay}	2.11 (0.19)^{ay}	2.26 (0.13)^{ay}
SON[2]	2.62 (0.04)^{ax}	——	2.42 (0.25)^{ax}	2.58 (0.25)^{ax}	2.69 (0.19)^{ax}
SOS[2]	2.31 (0.13)^{ay}	2.17 (0.21)^{ay}	2.24 (0.15)^{ay}	2.23 (0.18)^{ay}	2.37 (0.10)^{ay}
CSN[2]	2.66 (0.17)^{ay}	——	2.46 (0.06)^{ax}	2.46 (0.08)^{ax}	2.63 (0.12)^{ax}
CSS[2]	2.15 (0.12)^{ay}	1.91 (0.07)^{ay}	1.92 (0.21)^{ay}	2.19 (0.07)^{ay}	2.17 (0.04)^{ay}
NUN[2]	2.57 (0.11)^{ax}	——	2.76 (0.12)^{ax}	2.67(0.15)^{ax}	2.76 (0.17)^{ax}
NUS[2]	2.08 (0.04)^{ay}	1.92 (0.27)^{ay}	2.02 (0.29)^{ay}	1.90 (0.47)^{ay}	2.21 (0.28)^{ay}

[1]Years with the same letter within each treatment are not significantly different (P>0.05) (a,b and c).
[2]Treatments with the same letter are not significantly different (P>0.05) (x, y, and z).

Table 5. Herbage production (lb/acre) on the non-use control treatment in 1996, 1997, 1998,1999, and 2000. (Standard errors in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]
	lb/acre				
Grass & Grass-Like	1527 (146)[a]	1317 (168)[ab]	1060 (139)[b]	1609 (202)[a]	1652 (143)[a]
Forb	118 (43)[ab]	87 (29)[ab]	46 (23)[a]	171 (59)[b]	93 (53)[ab]
Shrub	82 (76)[a]	14 (13)[a]	14 (14)[a]	14 (12)[a]	10 (8)[a]
Leafy Spurge	407 (139)[ab]	446 (77)[ab]	350 (81)[a]	410 (92)[ab]	624 (173)[b]

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

Table 6. Livestock average daily gains (standard errors in parentheses) for individual livestock classes on the (CO) cattle only, (SO) sheep only, and (CS) cattle and sheep treatments for 1996, 1997, 1998, 1999, and 2000.

Treatment & Livestock Class[1]	1996[2]	1997[2]	1998[2]	1999[2]	2000[2]
	lb/day				
CO Steer	1.76 (0.07)[ax]	1.61 (0.13)[ax]	1.23 (0.06)[ax]	1.80 (0.25)[ax]	1.96 (0.24)[ax]
CS Steer	1.53 (0.32)[ax]	1.12 (0.16)[ax]	0.96 (0.13)[ax]	1.44 (0.22)[ax]	2.02 (0.10)[ax]
SO Ewe	0.16 (0.02)[ax]	0.07 (0.02)[bx]	0.04 (0.02)[bx]	0.09 (0.02)[abx]	0.20 (0.02)[ax]
CS Ewe	0.16 (0.02)[abx]	0.09 (0.03)[abx]	0.07 (0.02)[bx]	0.18(0.02)[abx]	0.22 (0.03)[ax]

[1]Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, and c).
[2]Treatments with the same letter within each livestock class are not significantly different (P>0.05) (x, y, and z).

Conclusions

Sheep grazing, either as a sole enterprise or mixed with cattle, will provide and effective tool in controlling leafy spurge by reducing stem densities. When replacing cattle AUM's with sheep AUM's, leafy spurge stem density counts were reduced by 94% in four years of grazing. When grazing sheep and cattle together, leafy spurge was reduced by 82% in four years. There were no negative or positive effects on species diversity grazing sheep or cattle alone or together after three grazing seasons. Grass and grass-like disappearance was similar among all grazing treatments, showing replacing cattle with sheep would not affect graminoid disappearance while reducing leafy spurge. There was no difference in livestock performance when grazing cattle and sheep separately or in combination, suggesting multi-species grazing had no negative or positive effects on livestock performance as it relates to weight gain in this study.

Literature cited

Barker, W.T. and W.C. Whitman. 1989. Vegetation of the northern Great Plains. Rangelands. 10:266-272.

Merrill, L.B., P.O. Reardon, and C.L. Leinweber. 1966. Cattle, sheep, goats...mix'em up for higher gains. Texas Agr. Prog. 12:13-14.

Prosser, C.W. 1995. Multi-species grazing of leafy spurge infested rangeland in North Dakota. M.S. Thesis. N.D. State Univ., Fargo. 80 pp.

Shiflets, T.N. 1994. Rangeland cover types of the United States. Soc. for Range Manage. Denver, CO. 152 pp.

SPSS. 1999. Statistical producers for Social Science. Marketing Dept. SPSS. Inc. Chicago, Ill.

Whitman, Warren, C., D.W. Bolin, E.W. Klostermann, K.D. Ford, L. Moomaw, D.G. Hoag, and M.L. Buchanan. 1951. Caroten, protein, phosphorus in grasses of western North Dakota. Agr. Exp. Sta., N.D. Agr. College. N. D. Agr. Exp. Sta. Bull. No. 370.