MULTI-SPECIES GRAZING AND SINGLE SPECIES GRAZING ON LEAFY SPURGE INFESTED RANGELAND (Eight-Year Summary)

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Impact Statement

Sheep or cattle/sheep grazing reduced leafy spurge stem density by 97% after eight years of grazing. However, sheep grazing alone achieved this reduction within 4 years, while cattle/sheep grazing required five years to achieve a similar reduction.

Introduction

Leafy spurge (*Euphorbia esula* L.) is North Dakota's most destructive noxious weed, invading over 1,200,000 acres of North Dakota land, primarily rangeland (North Dakota Dept. of Agriculture 2002). Leafy spurge has been reported in at least 35 states and six Canadian provinces (USDA, NRSCS 1999). This weed, which is extremely persistent and competitive, has contributed significantly to economic losses in the livestock industry. Thompson et al. (1990) estimated that land depreciation losses were over $137 million in North Dakota due to leafy spurge infestations. Leitch et al. (1994) reported that total direct and secondary annual impacts were over $86 million in North Dakota and over $129.5 million in the upper Midwest.

The use of sheep as a biocontrol agent in the control of leafy spurge is not a new concept. In the late 30's and early 40's Christensen et al. (1938), Helgeson and Thompson (1939) and Helgeson and Longwell (1942) indicated that sheep consumed leafy spurge and should be integrated into management strategies in controlling leafy spurge, however, there was limited promotion. Herbicides continue to be the primary method for control of leafy spurge (Lym et al. 1995). Many areas infested with leafy spurge, however, are in environmentally sensitive areas and most herbicides for controlling leafy spurge are not labeled for application in these sensitive areas. Therefore, many land managers have chosen alternative control agents, such as Angora goats or sheep. Research conducted in the 1980's and 1990's has shown that sheep or goats will reduce leafy spurge stem densities and increase grass and grass-like disappearance, and reported significant benefits in using multi-species grazing to manage leafy spurge infested rangelands (Prosser 1995).

Multi-species grazing allows rangeland managers to utilize a wider diversity of vegetation than single-species grazing (Merrill et al. 1966). The utilization of more than one livestock species on a rangeland containing various vegetative communities provides the potential of increasing species diversity, vegetative production, and ultimately red meat production. The economic losses associated with leafy spurge invasion require that the spread of leafy spurge is controlled and ultimately reversed. While it is known that sheep may help control the spread and actually reduce leafy spurge infestation, research is need that describes the long term trends in forb and shrub species density and richness, herbage production, and livestock gains resulting from multi- and single-species grazing of leafy spurge infested rangelands. No long term published research is available describing the ecological impact of multi- and single-species grazing with sheep and/or cattle, as well as the ideal rate at which to replace cattle with sheep to achieve leafy spurge reduction.

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 9 T138N, R81W of Morton county on native rangeland operated by the USDA-ARS 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-needlegrass (*Agropyron*, *Bouteloua*, *Stipa*) plant community (Shiflet 1994).

Grazing treatments were multi-species and single-species grazing on three replicated 20 acre blocks. Replicates one and two were within the North Dakota State Correction Center land and replicate three was on the USDA-ARS Northern Great Plains Research Laboratory. Each of the replicates were subdivided into 5 acre plots and the plots were treated with cattle only (**CO**), sheep only (**SO**), cattle and sheep (**CS**), or a non-use control (**NU**). Treatments were randomly allocated within each block in 1996, and treatments were applied through 2003. 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 was achieved, or before 15 September.

Stocking rates include two yearling steers for CO from 1996 to 2003; twelve mature ewes in 1996, ten-mature ewes 1997 and 1998, and seven mature ewes from 1999 to 2003 for SO; one yearling steer and six mature ewes in 1996 and one yearling steer and five mature ewes from 1997 to 2003 for CS. Stocking rates were approximately 1.5 AUM/acre for CO, SO, and CS. 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 adjusted sheep stocking rates for SO and CS were due to a decrease in leafy spurge production following treatment application.

Materials and Methods

Leafy spurge stem density counts were obtained using a permanent 109.4 yard line transect and counts collected approximately every 5 ½ yards using a 1.08 ft^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 eight years to evaluate the effectiveness of sheep grazing with single or multi-species management in the control of leafy spurge. Leafy spurge stem densities were evaluated at the end of May.

Forb and shrub species diversity and density was determined using a 2.7 ft^2 quadrat. Nested within the 2.7 ft^2 quadrat was a 1.08 ft^2 quadrat used to determine grass and grass-like species diversity. Data was collected from 109.4 yard transects with readings conducted approximately every 5 ½ 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) 109.4 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 in 1997 and 2003. The leafy spurge transects were monitored annually and will continue to be monitored annually throughout the ten-year trial.

Leafy spurge, grass and grass-like, shrub, and forb herbage production were determined by clipping in late July on the NU treatment when vegetative species reached peak production (Whitman et al. 1952). Each NU plot was stratified into 7.67 x7.67 yard grid. A 7.67 yard buffer strip was implemented to prevent an edge effect. Twenty-five plots were clipped on the grid within each NU plot using a 2.7 ft^2 quadrat.

Degree of disappearance of leafy spurge, grass and grass-likes, forbs, and shrubs were determined for each treatment at the end of the grazing season by stratifying each treatment into 7.67 by 7.67 yard quadrats in 1996, 1997, 1998, and 1999. Twenty-five quadrats were clipped within the grid using a 2.7 ft^2 quadrat for each grazed and non-use treatment to determine the degree of disappearance. The method of determining degree of disappearance was changed 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 and will continue throughout the duration of the trial. Five cages were systematically placed within each grazing treatment (CO, SO, and CS) in leafy spurge infested sites. Two frames within each cage and two out of each cage were clipped after the removal of livestock species.

Livestock performance and production were collected for both cattle and sheep by determining average daily gain (**ADG**) and gain per acre, respectively. Both classes of livestock were weighed prior to pasture turn out and 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 2000). Mean separation was performed using Tukey's Honesty Significant Difference when significant ($P \leq 0.05$) differences were found. 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 2000).

Results and Discussion

A significant ($P < 0.05$) reduction in leafy spurge stem density occurred after one grazing season for SO and again after two grazing seasons. Leafy spurge stem density was decreased ($P < 0.05$) after three years of grazing for CS. Leafy spurge was reduced from 10.4 stems/1.08 ft^2 in 1996 to 0.8/1.08 ft^2 stems in 1999 for SO; a reduction of 92% after four grazing seasons and 97% after eight grazing seasons. Leafy spurge stem densities were reduced ($P < 0.05$) by 97% after eight grazing seasons for CS, and were similar ($P < 0.05$) to SO by year 5. Leafy spurge stem density for CO and NU were reduced ($P < 0.05$) by 65 and 62%, respectively, after eight grazing seasons; however, reductions in years 6, 7, and 8 were probably the result of bio-control insects invading the research plots in 2001. Leafy spurge stem densities were reduced ($P < 0.05$) from 9.8 stems/1.08 ft^2 in 1996 to 3.4 stems/1.08 ft^2 in 2003 for CO, and from 9.8 stems/1.08 ft^2 in 1996 to 3.7 stems/1.08 ft^2 in 2003 for NU (Table 1).

Leafy spurge and non-infested range sites were significantly different ($P < 0.05$) in forb and shrub density at the beginning of the study in 1996. The main focus of the study was to evaluate the change of forb and shrub density on leafy spurge infested range sites over the course of the study. Non-infested range sites, however, were also evaluated separately from the leafy spurge infested sites throughout the duration of the study (Table 2). Results after seven grazing seasons demonstrate that no year or treatment effects were present ($P > 0.05$) on leafy spurge or non-infested range sites in the number of forb and shrub stems per 2.4 ft^2 (Table 2).

Plant species diversity (Shannon Weiner diversity index) results showed that there were significant differences ($P < 0.05$) between leafy spurge and non-infested range sites in all treatments in 1996. Again, our focus was to evaluate leafy spurge infested sites in each treatment to detect changes in plant species diversity. Results demonstrate that plant species diversity has not changed ($P > 0.05$) after seven grazing seasons on leafy spurge or non-infested range sites (Table 3).

Peak herbage production was different ($P < 0.05$) between growing seasons for graminoid, forb, and leafy spurge production (Table 4). These changes are the result of variation in annual precipitation and temperature. At the start of the study our hypothesis was that leafy spurge would have a negative effect on graminoid, forb, and shrub herbage production over time, however, results reported after eight grazing seasons do not support this hypothesis.

Leafy spurge degree of disappearance increased on all sheep treatments from 1996 to 2001. The SO treatment increased from 76% to 99% leafy spurge disappearance from 1996 to 2001, and the CS treatment increased from 62% to 97% from 1996 to 2000. There was an increase ($P < 0.05$) in leafy spurge disappearance in the CO treatment with 23% disappearance in 1996 compared to 50% in 1997 and 1998; however, it was reduced to 23% in 1999. The results for 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 because of a trampling effect. As graminoid disappearance increased for CO, so did leafy spurge disappearance. 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 ADG was not different (P > 0.05) between treatments (CO and CS) or among years after eight grazing seasons (Table 5). Ewe ADG exhibited yearly variation (P < 0.05), which was strongly correlated with yearly variation in graminoid production. There was no affect of treatment (P > 0.05) on ewe ADG. These results would suggest multi-species grazing had no significant negative or positive impact on sheep or cattle performance compared with single species grazing.

Conclusion

Sheep grazing, either as a sole enterprise or mixed with cattle is an effective tool in controlling leafy spurge. When replacing cattle AUM's with sheep AUM's, leafy spurge stem density was reduced by 97% after eight years of grazing. When grazing sheep and cattle together, leafy spurge stem density was reduced by 97% after eight years of grazing, however, the reduction took five years to achieve, while grazing with sheep alone took only four years to achieve a similar reduction. Species diversity was not affected by grazing sheep, cattle, or a mix of species after eight grazing seasons. Grass and grass-like disappearance was similar among all grazing treatments, showing replacing cattle with sheep would not affect grass and grass-like disappearance while simultaneously 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 effect on livestock performance, as it relates to weight gain, in this study.

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Table 1. Effect of multi- and single-species grazing on leafy spurge stem density (number/1.08 ft^2; SE in parentheses)

	Treatment[a]			
Year	CO	SO	CS	NU
1996	9.8 (0.9)[bxyz]	10.4 (0.7)[by]	11.6 (0.9)[bz]	9.8 (0.9)[bxy]
1997	12.0 (0.9)[cz]	6.7 (0.6)[bx]	12.3 (1.0)[cz]	11.4 (0.9)[cy]
1998	10.8 (0.7)[cxyz]	2.5 (0.4)[bw]	11.6 (1.2)[cyz]	11.1 (0.8)[cxy]
1999	11.1 (0.7)[dyz]	0.8 (0.1)[bw]	6.5 (0.7)[cxy]	10.5 (0.7)[dxy]
2000	7.6 (0.8)[cwxy]	0.6 (0.3)[bw]	2.1 (0.4)[bwx]	11.8 (0.8)[cy]
2001*	7.0 (0.7)[cwx]	0.5 (0.2)[bw]	1.2 (0.2)[bw]	7.3 (0.7)[cwx]
2002*	3.3 (0.4)[bw]	0.4 (0.1)[bw]	0.2 (0.1)[bw]	3.3 (0.5)[bw]
2003*	3.4 (0.6)[bw]	0.3 (0.1)[bw]	0.4 (0.1)[bw]	3.7 (0.5)[bw]
% Change	**65%**	**97%**	**97%**	**62%**

[a] CO = cattle only; SO = sheep only; CS = cattle and sheep; NU = control.
[b,c,d] Within a row, means without a common superscript differ ($P < 0.05$).
[w,x,y,z] Within a column, means without a common superscript differ ($P < 0.05$).
*Bio-control insects present (2001, bio-control insects were found in all treatments and reps).

Table 2. Effect of multi- and single-species grazing on forb and shrub species density (number/2.7 ft^2; SE in parentheses)

	Treatment[a]							
Year	CON	COS	SON	SOS	CSN	CSS	NUN	NUS
1996	6.7 (1.0)	1.8 (0.4)	5.8 (1.1)	1.1 (0.3)	4.5 (0.5)	0.9 (0.2)	7.8 (0.9)	1.1 (0.4)
1997	---	1.5 (0.4)	---	0.5 (0.2)	---	0.3 (0.1)	---	0.9 (0.3)
1998	4.1 (0.1)	1.3 (0.3)	2.1 (0.5)	0.8 (0.2)	2.3 (0.4)	0.8 (0.3)	6.9 (0.8)	1.0 (0.3)
1999	7.8 (1.1)	1.0 (0.3)	7.0 (1.5)	2.2 (0.5)	3.0 (0.4)	1.4 (0.4)	5.8 (0.7)	1.9 (0.5)
2000	9.5 (1.5)	1.1 (0.3)	6.0 (0.9)	1.7 (0.2)	3.5 (0.5)	0.9 (0.4)	6.1 (0.7)	1.6 (0.4)
2001	5.9 (0.7)	2.3 (0.5)	3.0 (0.4)	1.3 (0.2)	2.6 (0.3)	0.8 (0.2)	6.9 (0.8)	2.4 (0.7)
2002	4.4 (0.6)	0.9 (0.2)	2.3 (0.4)	1.2 (0.2)	2.0 (0.3)	0.7 (0.2)	5.8 (0.8)	1.1 (0.3)
2003	---	---	---	---	---	---	---	---

[a] CON = cattle only non-infested; COS = cattle only leafy spurge infested; SON = sheep only non-infested; SOS = sheep only leafy spurge infested; CSN = cattle and sheep non-infested; CSS = cattle and sheep leafy spurge infested; NUN = control non-infested; NUS = control leafy spurge infested.

Table 3. Effect of multi- and single-species grazing on Shannon Weiner diversity index (SE in parentheses)

	Treatment[a]							
Year	CON	COS	SON	SOS	CSN	CSS	NUN	NUS
1996	2.73 (0.17)	2.30 (0.07)	2.62 (0.04)	2.31 (0.13)	2.66 (0.17)	2.15 (0.12)	2.57 (0.11)	2.08 (0.04)
1997	---	2.23 (0.26)	---	2.17 (0.21)	---	1.91 (0.07)	---	1.92 (0.27)
1998	2.60 (0.10)	2.12 (0.13)	2.42 (0.25)	2.24 (0.15)	2.46 (0.06)	1.92 (0.21)	2.76 (0.12)	2.02 (0.29)
1999	2.60 (0.05)	2.11 (0.19)	2.58 (0.25)	2.23 (0.18)	2.46 (0.08)	2.19 (0.07)	2.67 (0.15)	1.90 (0.47)
2000	2.65 (0.14)	2.26 (0.13)	2.69 (0.19)	2.37 (0.10)	2.63 (0.12)	2.17 (0.04)	2.76 (0.17)	2.21 (0.28)
2001	2.71 (0.11)	2.21 (0.08)	2.55 (0.21)	2.28 (0.11)	2.51 (0.09)	2.23 (0.11)	2.40 (0.35)	2.24 (0.26)
2002	2.58 (0.09)	2.03 (0.23)	2.45 (0.14)	2.34 (0.09)	2.42 (0.25)	2.20 (0.04)	2.11 (0.41)	2.03 (0.23)
2003	---	---	---	---	---	---	---	---

[a] CON = cattle only non-infested; COS = cattle only leafy spurge infested; SON = sheep only non-infested; SOS = sheep only leafy spurge infested; CSN = cattle and sheep non-infested; CSS = cattle and sheep leafy spurge infested; NUN = control non-infested; NUS = control leafy spurge infested.

Table 4. Peak herbage production (lb/acre) for graminoids, forbs, shrubs, and leafy spurge on the control treatment (NU; SE in parentheses)

	Plant Type			
Year	Graminoid	Forb	Shrub	Leafy Spurge
1996	1529 (2.4)[bc]	117 (0.7)[ab]	83 (1.2)[a]	405 (2.3)[ab]
1997	1317 (2.7)[ab]	84 (0.5)[ab]	15 (0.2)[a]	445 (1.3)[ab]
1998	1058 (2.3)[a]	46 (0.4)[a]	15 (0.2)[a]	350 (1.3)[a]
1999	1608 (3.3)[bc]	170 (1.0)[b]	14 (1.0)[a]	409 (1.5)[ab]
2000	1651 (2.3)[bc]	95 (0.9)[ab]	9 (0.9)[a]	625 (2.4)[b]
2001*	2244 (2.6)[d]	91 (0.6)[ab]	29 (0.6)[a]	287 (1.3)[a]
2002*	1791 (2.3)[c]	48 (0.4)[a]	7 (0.4)[a]	251 (0.8)[a]
2003*	1419 (1.6)[abc]	90 (0.7)[ab]	82 (0.7)[a]	275 (0.9)[a]

[a,b,c] Within a column, means without a common superscript differ ($P < 0.05$).
*Bio-control insects present (2001, bio-control insects were found in all treatments and reps).

Table 5. Effect of multi- and single-species grazing on livestock average daily gains (lb/d; SE in parentheses)

	Treatment[a]			
Year	CO Steer	CS Steer	SO Ewe	CS Ewe
1996	1.76 (0.16)[bx]	1.53 (0.32)[bx]	0.16 (0.02)[byz]	0.17 (0.02)[bxy]
1997	1.61 (0.13)[bx]	1.12 (0.16)[bx]	0.07 (0.02)[bx]	0.12 (0.02)[by]
1998	1.23 (0.07)[bx]	0.96 (0.22)[bx]	0.04 (0.02)[bx]	0.08 (0.02)[bxy]
1999	1.89 (0.32)[bx]	1.44 (0.27)[bx]	0.12 (0.01)[bxy]	0.18 (0.02)[bxy]
2000	1.84 (0.29)[bx]	2.02 (0.10)[bx]	0.20 (0.02)[byz]	0.22 (0.03)[by]
2001	1.86 (0.17)[bx]	1.72 (0.33)[bx]	0.23 (0.02)[bz]	0.20 (0.03)[by]
2002	1.33 (0.14)[bx]	1.55 (0.30)[bx]	0.13 (0.02)[bxyz]	0.21 (0.01)[by]
2003	1.39 (0.18)[bx]	1.17 (0.34)[bx]	0.04 (0.04)[bx]	0.06 (0.03)[bx]

[a]CO Steer = steer average daily gain for cattle only treatment; CS Steer = steer average daily gain for the cattle and sheep treatment; SO Ewe = ewe average daily gain for the sheep only treatment; CS Ewe = ewe average daily gain for the cattle and sheep treatment.
[b] Within a row, means without a common superscript differ ($P < 0.05$).
[x,y,z] Within a column and livestock species, means without a common superscript differ ($P < 0.05$).