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

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Impact Statement

Sheep or cattle/sheep grazing reduced leafy spurge stem density by 99% after ten 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 2005. 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 2005; twelve mature ewes in 1996, ten-mature ewes 1997 and 1998, and seven mature ewes from 1999 to 2005 for SO; one yearling steer and six mature ewes in 1996 and one yearling steer and five mature ewes from 1997 to 2005 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.

Leafy spurge, grass and grass-like, shrub, and forb herbage production were determined by clipping in late July in all treatments when vegetative species reached peak production (Whitman et al. 1952). Each plot was stratified into 7.67 x 7.67 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 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. 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 GLM procedure of SAS (SAS Inst. Inc., Cary, NY). 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.

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 (Table 1). 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 99% after ten grazing seasons. Leafy spurge stem densities were reduced ($P < 0.05$) by 99% after ten 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 91 and 89%, respectively, after ten grazing seasons; however, reductions in years 6 through 10 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 0.9 stems/1.08 ft^2 in 2005 for CO, and from 9.8 stems/1.08 ft^2 in 1996 to 1.1 stems/1.08 ft^2 in 2005 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 (Table 2). A treatment x site (leafy spurge or native) interaction was observed after ten grazing seasons for forb and shrub density ($P = 0.002$) as well as graminoid density ($P = 0.01$). However, when analyzing the data within treatment, it appears little change has occurred in the native and leafy spurge infested sites as leafy spurge stem density decreased over time (Tables 2 and 3).

Peak herbage production is listed in Table 4. Changes in production are the result of variation in annual precipitation and temperature. Steer ADG did not exhibit a treatment by year interaction ($P = 0.91$) or a treatment effect ($P = 0.18$). However, a year effect ($P = 0.05$) was observed. While extreme variation in performance exists, it appears the majority of the variation is related to precipitation events (Tables 4 and 5). However, ewe ADG exhibited a treatment by year interaction ($P < 0.001$). But once again, much of the variation appears to be linked to precipitation events (Table 5). 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 99% after ten years of grazing. Similarly, when grazing sheep and cattle together, leafy spurge stem density was reduced by 99% after ten years of grazing. However, the reduction took five years to achieve for cattle and sheep grazing, while grazing with sheep alone took only four years to achieve a similar reduction. Large differences in forb, shrub, and grass species diversity do not appear to be present after ten grazing seasons. While subtle differences exist for livestock performance on a treatment basis, it appears that the majority of variation for livestock performance is precipitation related, not related to multi-species grazing.

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Table 1. Effect of multi- and single-species grazing on leafy spurge stem density/ 1.08 ft^2

	Treatment[a]				
Year	**CO**	**SO**	**CS**	**NU**	**SEM[b]**
1996	9.8	10.4	11.6	9.8	1.9
1997	12.0	6.8	12.3	11.4	1.9
1998	10.8	2.5	11.8	11.1	1.9
1999	11.1	0.8	6.5	10.5	1.9
2000	6.2	0.6	2.1	8.1	1.9
% Change	**37%[x]**	**94%[y]**	**82%[y]**	**17%[x]**	**---**
2001[c]	5.0	0.3	0.8	5.4	1.9
2002[c]	2.5	0.3	0.2	2.3	1.9
2003[c]	3.4	0.3	0.4	3.7	1.9
2004[c]	2.0	0.3	0.3	1.2	1.9
2005[c]	0.9	0.1	0.1	1.1	1.9
% Change	**91%[x]**	**99%[x]**	**99%[x]**	**89%[x]**	**---**

[a] CO = cattle only; SO = sheep only; CS = cattle and sheep; NU = control.

[b] Standard Error of Mean; n = 3.

[c] Bio-control insects present in all treatments and replications.

[xy] Within a row, means without a common superscript differ ($P < 0.05$).

Table 2. Effect of multi- and single-species grazing on forb and shrub species density/2.7 ft^2

	Treatment[a]									
Year	CON	COS	SON	SOS	CSN	CSS	NUN	NUS	SEM[b]	*P*[c]
1996	6.7[d]	1.8[e]	5.8[d]	1.1[e]	4.5[d]	0.9[e]	7.8[d]	1.1[e]	1.10	< 0.002
2005	5.0[d]	10.9[e]	1.8[d]	1.2[d]	1.9[d]	1.7[d]	8.0[d]	13.0[d]	1.96	< 0.002

[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.
[b]Standard Error of Mean; n = 3.
[c]*P*-value for F-test of treatment
[d,e] Within a row and treatment, means without a common superscript differ ($P < 0.05$).

Table 3. Effect of multi- and single-species grazing on graminoid species density/1.08 ft^2

	Treatment[a]									
Year	CON	COS	SON	SOS	CSN	CSS	NUN	NUS	SEM[b]	*P*[c]
1996										
2005	3.2[d]	2.5[d]	3.7[d]	3.8[d]	2.6[d]	3.6[d]	1.5[d]	2.1[d]	0.43	0.01

[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.
[b]Standard Error of Mean; n = 3.
[c]*P*-value for F-test of treatment
[d] Within a row and treatment, means without a common superscript differ ($P < 0.05$).

Table 4. Peak herbage production (lb/acre) for graminoids, forbs, shrubs, and leafy spurge for 1996 through 2005

	Treatment			
Year	Graminoid	Forb	Shrub	Leafy Spurge
1996	1529	117	83	405
1997	1317	84	15	445
1998	1058	46	15	350
1999	1608	170	14	409
2000	1651	95	9	625
2001*	2244	91	29	287
2002*	1791	48	7	251
2003*	1419	90	82	275
2004*	1591	84	18	147
2005*	1499	250	107	285

*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	Steer	SEM[b]	SO Ewe	CS Ewe	SEM
1996	1.65^{wxy}	0.18	0.16^{uvw}	0.16^{wxyz}	0.04
1997	1.36^{xyz}	0.18	0.08^{wxy}	0.09^{xyz}	0.05
1998	1.09^{z}	0.20	0.03^{y}	0.06^{z}	0.05
1999	1.66^{wxy}	0.18	0.11^{vwxy}	0.18^{wxyz}	0.05
2000	1.93^{w}	0.18	0.20^{uv}	0.22^{w}	0.05
2001	1.79^{wx}	0.18	0.23^{u}	0.20^{wxy}	0.05
2002	1.44^{wxyz}	0.18	0.13^{uvwx}	0.21^{wx}	0.05
2003	1.28^{yz}	0.18	-0.31^{cz}	0.06^{dz}	0.05
2004	1.24^{yz}	0.18	0.11^{vwxy}	0.11^{wxyz}	0.05
2005	1.31^{xyz}	0.18	0.04^{xy}	0.08^{yz}	0.05

[a]Steer = average daily gain for steers for both treatments; SO Ewe = ewe average daily gain for the sheep only treatment; CS Ewe = ewe average daily gain for the cattle and sheep treatment.
[b]SEM = Standard Error of Mean; n = 3.
[cd]Within a row and species, means without a common superscript differ ($P < 0.05$).
[wx,yz]Within a column and livestock species, means without a common superscript differ ($P < 0.05$).