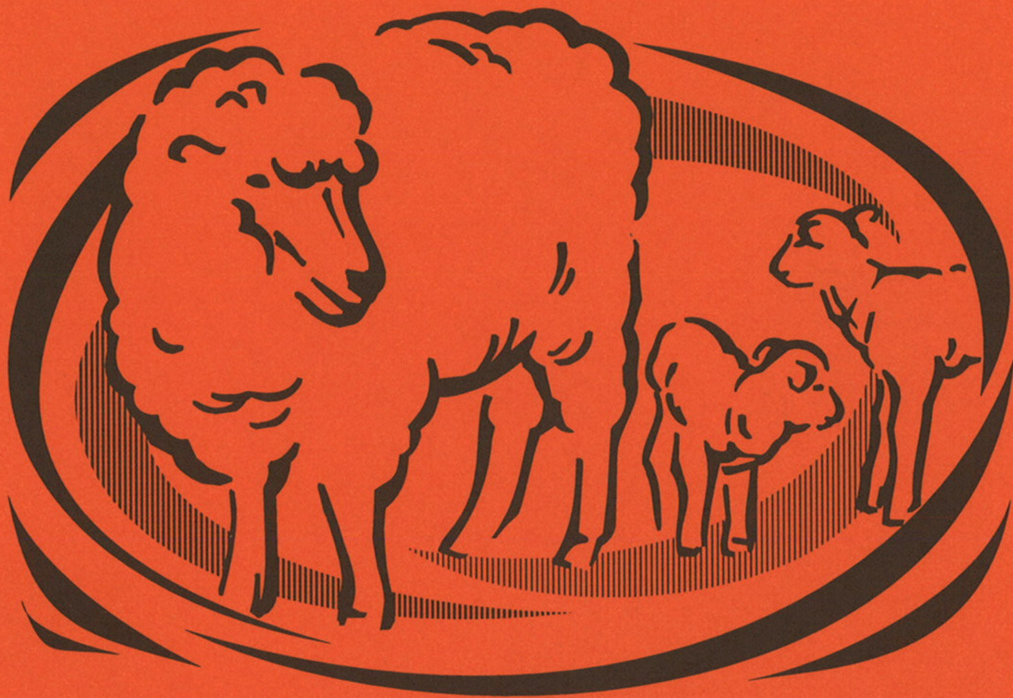
REPORT NO. 41



WESTERN DAKOTA SHEEP DAY

February 9, 2000

HETTINGER ARMORY

Hettinger Research Extension Center
and
Department of Animal and Range Sciences
North Dakota State University

February 9, 2000

Dear Sheep Producer:

On behalf of the Hettinger Research Extension Center and the Department of Animal and Range Sciences, let us welcome you to "Sheep Day". This report collectively represents North Dakota State University's efforts at both locations to provide information for the support of the sheep industry. We welcome your comments as grassroots users of the efforts of both Extension and Experiment Station resources. Your constructive comments assist us to participate meaningfully in the future of your industry.

A collective, positive and participatory attitude by producers and caretakers of their land grant resources will go far to solve problems confronting the sheep industry.

Best wishes for a day of sharing and learning.

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SHEEP DAY DIGEST

by
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PROGRAM

9:00-10:00 AM (MST) **OPEN HOUSE** at barns to tour projects and view the rams on the "RAM TEST"

9:30 AM	**DOORS OPEN** - and coffee at Hettinger Armory
10:10 AM	Early Bird Door Prize Drawing
10:15 AM	**HETTINGER & FARGO STATION REPORTS** Dr. Paul Berg Dr. Marc Bauer Mr. Erik Loe Mr. Jack Dahl & Mr. Lyndon Johnson Dr. Jeff Held Mr. Tim Faller & Mr. Dan Nudell
12:00 NOON	**LUNCH: AMERICAN LAMB DINNER**
1:00 PM	**OPENING COMMENTS:** Dr. Joe Chapman, President North Dakota State University
1:10 PM	**"POSITIONING LAMB PRODUCERS TO BE COMPETITIVE IN THE U.S. MARKET" (LIVE ANIMAL AND CARCASS MERIT DISCUSSION)** Roger Haugen, North Dakota State University Jeff Held, South Dakota State University Paul Berg, North Dakota State University
1:55 PM	**"ECONOMIC CONSIDERATION OF LEAFY SPURGE CONTROL"** Dean Bangsund and Larry Leistritz North Dakota State University
2:15 PM	**"FEASIBILITY OF LARGE SCALE SHEEP PRODUCTION COOPS"** Randy Sell, North Dakota State University and Dan Nudell, Hettinger Research Extension Center
2:35 PM	**"SERVICES AND FUTURE TRENDS FOR PREDATORY ANIMAL CONTROL"** Phil Mastrangelo, North Dakota Director USDA Wildlife Services
2:45 PM	**"REFLECTIONS ON THE PAST AND A VIEW OF THE FUTURE"** Leroy Johnson, Past Superintendent of HREC Sheridan, Wyoming
3:10 PM	**"CLOSING COMMENTS"** Burt Pfliger, President North Dakota Lamb and Wool Producers Association

*Also featured that day at 1:00 PM will be **"BRIDAL DRESSES OF A CENTURY"**
hosted by Adams County **F**amily **C**ommunity **E**ducation Clubs.
Colleen Svingen, Adams County Extension Agent and West River Health Services Wellness Educator, Hettinger, North Dakota will be the coordinator.

Lean Lamb Divergent Selection Project Update

Objective 2: To evaluate genetic and environmental strategies to improve efficiency of lean tissue accretion in lamb.

The preliminary reports concerning the divergent selection project which have been presented in the past two years (Berg and Faller, 1998 and 1999) have pointed out the difficulty encountered by attempting to lower the generation interval by using ram lambs as service sires. . This past year was the first lamb crop in which analyzable numbers were born to selected sires.

Finished lambs which have been slaughtered within the protocol of the lean lamb project (HES 1790) have largely been marketed through an arrangement with retail grocers in the Fargo-Moorhead area. As such the demand is limited and lambs are often held on feed longer than would be the case if strict production principles were followed. While this practice has allowed the comparison of lambs over a very wide range of carcass weights and there-by aided in the overall evaluation of Bioelectrical Impedance as a selection tool, a refinement of technique was required to help determine if selection for lean tissue accretion under a more practical setting. Beginning in 1998, rams from the divergent selection portion of the lean lamb project were selected and mated to a flock of western white-face ewes. Four rams from each of the High Lean (HL) and High Fat (HF) line were chosen as service sires. The first lambs from these matings were slaughtered during 1999. Standard carcass data was recorded and converted to pounds of closely trimmed retail product and fat according to the method described by Maddux (1997). The data was regressed to a standard carcass weight of 60 pounds for comparison of the sire groups. Sire group averages are presented in table 1. At this early stage of the project, differences between sire progeny are small. Differences in sire group means are apparent, but the ram whose offspring has the most lean and least fat was identified as a "low lean" sire, while the ram with the least lean and most fat was identified as a "high lean" sire. Numbers of offspring within each sire group are low so no conclusions may yet be drawn. The questions suggested by these very preliminary numbers are:

Is the bioelectrical impedance selection formula developed by Maddux (1997) the problem? (with respect to accuracy)

Is the difficulty with the theory that lean tissue accretion is strictly a quantitative genetic trait and there-bye subject to selection pressure.

Only time and more observations will provide answers for these questions.

Summary of Sire Groups

Sire	Status	N	Adj.# lean	Adj % lean	Adj # fat
C3507	Low Lean	3	36.8	62.3	14.0
C2303	Low Lean	7	37.0	62.6	13.8
C3572	Low Lean	12	36.7	62.1	14.1
N2833	Low Lean	10	35.7	60.5	15.1
	Average Low Lean	32	36.51	61.68	14.34
B6510	High Lean	11	35.7	60.8	14.9
B9104	High Lean	9	35.7	60.4	15.2
C3508	High Lean	11	36.6	61.5	14.5
C3569	High Lean	6	36.3	61.4	14.6
	Average High Lean	37	36.13	61.03	14.78
	Overall Average	69	36.25	61.34	14.57

COMPARISON OF COMPANION VERSUS SINGLE SPECIES GRAZING ON RANGELANDS INFESTED WITH LEAFY SPURGE (A Four-Year Summary)

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We would like to give a special and well-deserved thanks to the Hettinger Research Extension Center staff (Rick Olson, Dave Pearson, Dennis Bentsen, and Terri Lindquist). Also we would like to thank Dennis Whitted and Dr. Chad Prosser for their help in collecting data.

Introduction
In the past twenty years grazing animals as a biological control for leafy spurge has become an acceptable management practice. Research has showed grazing goats with cattle increased grass and grass-like disappearance by cattle, reduced leafy spurge stem densities, and reduced overall leafy spurge production after two grazing seasons (Prosser et al. 1995). Recent research has also has shown that sheep will reduce leafy spurge stem densities and also increase grass and grass-like disappearance, and there is significant benefit using multi-species grazing to better manage leafy spurge infested rangelands (Prosser 1995).

The objective of this study were to test the effects of companion 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 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 1988) 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) and 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 when leafy spurge as ready for grazing 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 matures 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 were due the adjustment in leafy spurge control and range condition.

Methods

Leafy spurge density counts were obtained by using a permanent 109 yard line transect and counts collected approximately every 5 ½ 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 density were monitored over the two years to determine effectiveness of sheep grazing to control. Leafy spurge densities were collected annually around the end of May.

Forb and shrub species frequency, density, richness, and diversity were determined using a 24 inch^2 quadrat. Nested within the 24 inch^2 quadrat was a 12 inch^2 quadrat which was used to determine graminoid species frequencies, richness, and diversity. Data was collected from 109 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 (no leafy spurge) 109 yard transect was located within each replicated treatment to monitor species diversity and richness changes that may naturally occur due to treatment. Readings were collected from the native transects annually, with the exception of 1997. The leafy spurge transects were monitored annually and will continued to be monitored annually throughout the ten year trial.

The ten-pin point frame was used to determine basal cover (Levy and Madden 1933) as modified by Smith (1959) and described by Mueller-Dombois and Ellenberg (1974). Basal cover was determined in 1996 and will be monitored biennially throughout the duration of the trial. The ten-pin point frame measurements were collected from the same 109 yard transects used for species diversity and richness on both native and leafy spurge sites, and collected every yard.

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 7 ½ by 7 ½ yard plot. A 7 ½ yard buffer 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 use of leafy spurge, graminoids, forbs, and shrubs were determined for each treatment at the end of the grazing season by stratifying each treatment into 7 ½ by 7 ½ yard quadrats. Twenty-five quadrats were randomly selected and clipped using 24 $inch^2$ quadrat on each grazed and nonuse treatment to determine the degree of disappearance.

Livestock performance and production were collected for both cattle and sheep by determining average daily gain and gain per hectare, 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 end of grazing season.

Treatment and year effects for leafy spurge stem density, species richness, forb and shrub density, herbage production, degree of use, and livestock performance 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 leafy spurge infested range sites. Treatment and year effects of species diversity was 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 0.8 stems in 1999, a reduction of 36% after one grazing season and 92% after three on the SO. Leafy spurge stem densities were not affected after two grazing seasons on the CS treatment, but were lower in 1999 compared to 1996, 1997, and 1998. Leafy spurge stems were reduced ($P<0.05$) from 11.6 stems/12 $inch^2$ in 1996 to 6.5 in 1999, a reduction of 44% after three 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).

Graminoid species richness significantly changed ($P \leq 0.05$) over the grazing seasons within treatments on non-infested and leafy spurge infested range sites. After three grazing seasons graminoid richness increased ($P<0.05$) from 9.7 + 1.2 (SE) to 10.7 + 1.7 (SE) graminoid species on leafy spurge infested sites in the CS treatment. The NU treatment decreased ($P<0.05$) in graminoid richness on non-infested range sites from 9.3 + 1.3 (SE) to 9.0 + 1.2 (SE) graminoid species from 1996 to 1999, and on the NU leafy spurge infested range sites graminoid species decreased ($P<0.05$) from 8.0 + 0.7 (SE) treatment from 1996 to 1999. The SO treatment had a decrease ($P<0.05$) in graminoid richness from 10.3 + 1.9 (SE) to 8.7 + 0.9 (SE) on leafy spurge infested range sites from 1996 to 1999.

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, and 1998.

	CO^2	SO^2	CS^2	NU^2
	# of Stems/12 inch^2 quadrat			
1996[1]	9.8 (1.2)^{ax}	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**

[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).

Graminoid species richness was significantly ($P<0.05$) different between non-infested and leafy spurge infested range sites within treatments. Cattle only and NU treatments non-infested range sites was higher ($P<0.05$) in graminoid richness than leafy spurge infested range sites, 9.3 + 0.7 (SE) to 8.3 + 0.7 (SE) on the CO, 10.3 + 1.9 (SE) to 8.7 + 2.7 (SE) on the NU, in 1998. The SO leafy spurge infested range sites (10.7 + 1.8 (SE)) was higher ($P<0.05$) than non-infested range sites (9.3 + 1.2 (SE)) in 1998. Results also showed that there was no difference ($P>0.05$) between non-infested and leafy spurge infested range sites in graminoid richness within treatments in years 1996 and 1999.

Treatment effects were present between non-infested and leafy spurge infested range sites in graminoid richness 1997, 1998, and 1999. Graminoid richness on the SO leafy spurge infested range sites were higher ($P<0.05$) than NU leafy spurge infested in 1997. Cattle only treatment non-infested range sites were lower ($P<0.05$) in graminoid richness than CS treatment non-infested range sites in 1998. The NU non-infested range sites were greater ($P<0.05$) in graminoid richness than CO and SO non-infested range sites in 1998. The SO non-infested range sites were lower ($P<0.05$) than CS non-infested range sites in 1998. Non-use control leafy spurge infested range sites were higher ($P<0.05$) in graminoid species richness than the CS leafy spurge infested range sites in 1998, however, the NU leafy spurge infested range sites was lower ($P<0.05$) than SO leafy spurge infested range sites in graminoid richness in 1998. The NU non-infested range sites were lower ($P<0.05$) in graminoid richness than the CO, SO, and CS non-infested range sites in 1999. Leafy spurge infested range sites on the NU treatment were also lower ($P<0.05$) than SO and CS leafy spurge infested range sites in graminoid richness in 1999. The SO treatment leafy spurge infested range sites were also greater ($P<0.05$) than the CO treatment leafy spurge infested range sites in graminoid richness in 1999.

Forb and shrub species richness was significantly ($P<0.05$) different between non-infested and leafy spurge infested range sites within treatments. Treatments CO and NU non-infested range sites were higher (P<0.05) than leafy spurge infested range sites in years 1996, 1998, and 1999. Treatments SO and CS treatments non-infested range sites were higher (P<0.05) than leafy spurge infested range sites in years 1996 and 1999.

Forb and shrub species richness were also different (P<0.05) between treatments in 1998 and 1999. The NU treatment non-infested range sites were significantly higher (P<0.05) in forb and shrub richness than non-infested range sites on the CO, CS, and SO treatments in 1998. Forb and shrub richness on the non-infested range sites CS treatment was lower (P<0.05) than the NU non-infested range sites in 1999. There was no significant (P>0.05) difference between treatments on leafy spurge infested range sites in 1996, 1997, 1998, and 1999.

Forb and shrub density were significantly (P<0.05) different between non-infested and leafy spurge infested range sites within treatments. Results showed non-infested range sites were greater (P<0.05) in forb and shrub density, in all treatments, than leafy spurge infested sites in 1996 and 1999. The only treatment that showed a significant difference in non-infested and leafy spurge infested in 1998 was the NU treatment, which leafy spurge infested range sites were lower (P<0.05) than non-infested range sites (Table 2). Results showed that there were significant year effects on the CO and SO treatments on the non-infested range sites. The SO treatment increased (P<0.05) in forb and shrub density from 1996 to 1999 and there was a increase in forb density on the CO non-leafy spurge range sites from 1998 to 1999. Results also showed that there were differences (P<0.05) among treatments on non-infested leafy spurge (Table 2). The densities on non-infested range sites on the CS treatment were lower (P<0.05) than the NU treatment in 1996 and 1998. Sheep only treatment non-infested range sites densities were greater (P<0.05) than NU non-infested sites in 1998. Both the CO and SO treatments non-infested range sites were greater (P<0.05) than the CS treatment non-infested range sites in 1999 (Table 2).

Species diversity results showed that there were significant (P<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<0.05) in species diversity than leafy spurge infested sites. Results also showed that species diversity did not change (P>0.05) after three grazing seasons and there was no treatment or year effect present after the three years of grazing.

Herbage production was different (P<0.05) between growing seasons in graminoid lb/acre and forb lb/acre. Results showed that graminoid lb/acre was lower (P<0.05) in 1998 than 1996 and 1999, however, was similar (P>0.05) between 1997 and 1998. Forb production results showed that forb lb/acre was higher (P<0.05) in 1999 than 1997 and 1998. Results would also indicate that leafy spurge has not effected shrub lb/acre after four growing seasons. Leafy spurge production did not change (P<0.05) after for growing seasons (Table 3).

Table 2. 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, and 1998. (Standard errors in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]
		Density/24 inch^2 quadrat		
CON[2]	6.7 (1.0)^{abxz}	----	4.1 (0.1)^{ax}	7.8 (1.1)^{bxz}
COS[2]	1.8 (0.4)^{ay}	1.5 (0.4)^{ax}	1.3 (0.3)^{ax}	1.0 (0.3)^{ay}
SON[2]	5.8 (1.1)^{axz}	----	2.1 (0.5)^{bx}	7.0 (1.5)^{ax}
SOS[2]	1.1 (0.3)^{ay}	0.5 (0.2)^{ax}	0.8 (0.2)^{ax}	2.2 (0.5)^{ay}
CSN[2]	4.5 (0.4)^{ax}	----	2.3 (0.4)^{ax}	3.0 (0.4)^{ay}
CSS[2]	0.9 (0.2)^{ay}	0.3 (0.1)^{ax}	0.8 (0.3)^{ax}	1.4 (0.4)^{ay}
NUN[2]	7.8 (0.9)^{az}	----	6.9 (0.8)^{az}	5.8 (0.7)^{az}
NUS[2]	1.1 (0.4)^{ay}	0.9 (0.3)^{ax}	1.0 (0.3)^{ax}	1.9 (0.5)^{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 3. Herbage production (lb/acre) on the non-use control treatment in 1996, 1997, 1998, and 1999. (Standard errors in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]
		lb/acre		
Grass & Grass-Like	1543 (128)^{a}	1325 (157)^{ab}	1041 (77)^{b}	1803 (281)^{a}
Forb	119 (42)^{ab}	84 (25)^{a}	46 (13)^{a}	190 (0.3)^{b}
Shrub	79 (61)^{a}	13 (10)^{a}	15 (8)^{a}	15 (9)^{a}
Leafy Spurge	339 (66)^{a}	396 (64)^{a}	350 (47)^{a}	464 (173)^{a}

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

Leafy spurge degree of disappearance increased on all sheep treatments form 1996 to 1999. The SO treatment went from 76% to 99% leafy spurge disappearance from 1996 to 1999, and the CS treatment went from 62% to 97% from 1996 to 1999. 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, reduced again to 23% in 1999. These results in leafy purge disappearance on the CO treatment would indicate 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 affect. As graminoid disappearance increased on CO treatment, so did leafy spurge disappearance, indicating with 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, were 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 4). 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 were significantly higher (P,0.05) in 1999 than the 1998 grazing season (Table 4). These results would indicate multi-species grazing had no negative or positive impact on sheep or cattle performance compared to single species grazing.

Table 4. 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, and 1999.

Treatment & Livestock Class[1]	1996[2]	1997[2]	1998[2]	1999[2]
	lb/day			
CO Steer	1.76 (0.07)[a]	1.61 (0.13)[a]	1.23 (0.06)[a]	1.80 (0.25)[a]
CS Steer	1.53 (0.32)[a]	1.12 (0.16)[a]	0.96 (0.13)[a]	1.44 (0.22)[a]
SO Ewe	0.16 (0.02)[y]	0.07 (0.02)[yz]	0.04 (0.02)[z]	0.09 (0.02)[y]
CS Ewe	0.16 (0.02)[y]	0.09 (0.03)[yz]	0.07 (0.02)[z]	0.18 (0.02)[y]

[1] Years with the same letter within each treatment are not significantly different (P>0.05).
[2] Treatments with the same letter within each livestock class are not significantly different (P>0.05).

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 92% after three years of grazing. When grazing sheep and cattle together, leafy spurge was reduced by 44% after three years. There were no negative or positive effects on species diversity grazing sheep or cattle alone or together after three grazing seasons. Graminoid disappearance was similar among all grazing treatments, indicating replacing cattle with sheep would not effect graminoid disappearance while reducing leafy spurge. There was no difference in livestock performance when grazing cattle and sheep separately or in combination, indicating multi-species grazing had no negative or positive effects on livestock performance as it relates to weight gain in this study.

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Nutrient Composition of Selected Warm-season Grasses: Preliminary Report

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Introduction

Warm-season grasses are planted in North Dakota for mid to late summer pastures, hay land, wildlife habitat, roadside right-a-ways, and set aside acres. However, warm-season plantings are somewhat atypical in North Dakota due to dominating cool-season species. But, for many years, new varieties/cultivars of warm and cool-season grasses have been established and released by plant materials centers around the country. Grasses of the same species can take on different forms due to their point of origin. These ecotypical species have great potential for adding more diversity to a producer's forage supply. Whatever a producer desires from a grass species, evaluation of ecotypical species can have great importance to decision-making.

Meeting the nutritional requirements of domestic livestock is the key to optimizing performance on and off pasture. Crude protein (CP) content, acid detergent fiber (ADF), and total digestible nutrients (TDN) comprise the majority of values needed to develop feed requirements for domestic livestock (Nutrient Requirements of Beef Cattle 1996). It is generally known that as grasses mature, they decline in nutritional quality. Knowledge of the nutritional concentrations of these warm-season grasses can be used by livestock producers to obtain optimum performance through the addition of proper management and timely supplementation during the grazing season when nutritional requirements are deficient.

Many ranchers of the northern Great Plains have an overabundance of cool-season forage and would benefit from the high quality forage that warm-season grasses produce in July and August (Tober and Chamrad 1992). Likewise, many cost cutting measures are focused on the mechanical side of ranching, when more attention should be directed towards cutting feed costs (Ricketts 1994). To best suit these needs, nutritional content of the grasses, production potential, and best use based on plant phenology and production are needed to address these concerns. With the advent of such knowledge and the potential to improve cattle performance on a regional basis, a need has developed to determine the nutrient content and forage production potential of selected warm-season grasses in the Northern Great Plains region.

The primary objectives of this study are to 1) determine and compare the nutrient content by date and phenological growth stage of the 16 warm-season grasses, 2) determine and compare forage production levels, and 3) develop management recommendations on proper use of these grasses.

Study Area

The two locations selected for this study are near Hettinger, ND and Pierre, SD. The Hettinger site is located on private land approximately 2 miles south of Hettinger, ND. It lies on the Verbar-Flasher-Parshall soil association, with a sandy loam soil texture (Ulmer and Conta 1987). The Pierre site is located north of Ft. Pierre, SD, on land managed by the U.S. Army Corps of Engineers. Soils on the Pierre site are a Promise clay with nearly level slope, a high shrink-swell potential, and restrictive root growth (Bismarck PMC, 1992).

Thirty-three different varieties or experimental lines were seeded in 3.5m by 15m plots on May 20-21, 1986 at the Pierre site. The Hettinger site had 16 tested varieties seeded in 2m by 8m plots on May 20, 1997. Seeding rate varied with species but followed recommended seeding rates as specified in the North Dakota NRCS Technical Guide. Species with no specified seeding rates were planted at 20-25 seeds/0.1m^2.

The climatic condition in both sites is a continental climate characterized by continuous air movement and large annual, daily, and day-to-day temperature changes. Relative humidity is low and precipitation tends to be irregular in time and cover (Jensen 1972).

Average annual precipitation in the Hettinger area is near 16 inches, and 14.7 to 18.7 inches in the Pierre area. Most precipitation occurs during the growing season. Seventy-seven percent of the annual precipitation falls during the summer months, with 50 percent falling during May, June, and July (Bavendick 1952). On average for the year, the temperature is 44 to 48 degrees F with a 130 to 160 day freeze-free period.

During the summer of 1999, temperatures were normal to above normal during clipping trials. From mid to late July, extreme temperatures occurred throughout much of the country, with temperatures reaching 100+ degrees F in the Pierre area for many consecutive days. Precipitation was relatively normal throughout the summer at both locations.

Grasses Studied

Sixteen grasses were selected to be analyzed for nutrient and forage production in 1999. A total of eight grass species will be tested encompassing 16 cultivars (Table 1).

Table 1. List of grass species and cultivar of each warm-season grass tested near Hettinger, ND, and Pierre, SD 1999.

Grass Species	Common Name	Cultivar
Andropogon gerardii	Big bluestem	Bison
Andropogon gerardii	Big bluestem	Sunnyview
Andropogon hallii	Sand bluestem	Garden*
Andropogon hallii	Sand bluestem	Goldstrike*
Bouteloua curtipendula	Sideoats grama	Butte
Bouteloua curtipendula	Sideoats grama	Pierre
Bouteloua gracillis	Blue grama	Bad River*
Bouteloua gracillis	Blue grama	Willis*
Calamovilfa longifolia	Prairie sandreed	Goshen
Calamovilfa longifolia	Prairie sandreed	ND-95
Panicum virgatum	Switchgrass	Dacotah
Panicum virgatum	Switchgrass	Forestburg
Schizachyrium scoparium	Little bluestem	Badlands*
Schizachyrium scoparium	Little bluestem	Camper
Sorghastrum nutans	Indiangrass	Holt
Sorghastrum nutans	Indiangrass	Tomahawk

* Grass cultivar was not sampled at Pierre, SD site.

Methods and Procedures

Nutritional quality and forage production were determined from ungrazed, non-mowed warm-season grass clippings at six time periods throughout the growing season beginning late June and ending early October. An array of 16 warm-season grass cultivars were seeded in 2m by 8m plots at the Hettinger site on May 20, 1997. Also, arrays of 33 warm-season cultivars were seeded in 3.5m by 15m plots at the Pierre site on May 20-21, 1986. Only 11 of these 33 cultivars will be analyzed in this study. Three replicated arrays were developed and each grass cultivar randomly seeded in each array to create a randomized complete block design (RCBD).

This nutritional quality and forage production trial began in June of 1999. Forage production was determined for the Pierre, SD site in 1999, while nutritional quality was determined for both sites. Each plot was subdivided into six quadrants of equal size that correlated to a clipping period. The six clipping periods were randomly selected for each plot. Samples were clipped in a similar random fashion at the Hettinger, ND site; however, sample sizes only had to be large enough for nutritional analysis. Each of the grass cultivars were tested for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), phosphorus, calcium, copper, zinc, magnesium, molybdenum, iron, potassium, and manganese. Forage production was determined for each of the grass cultivars at the Pierre site for each clipping period to determine peak herbage production and seasonal growth patterns. Crude protein and peak production will be summarized in this report.

The first clipping period was conducted June 21, 23 and 24, 1999. Six clipping periods occurred in 1999 at three-week intervals. Samples from the Pierre site were collected from each plot using a 0.5 m2 frame placed in its designated quadrant as randomly selected for each clipping period. Samples from Hettinger were taken using a random block approach; yet, frame size was not a factor. Grasses were clipped to a 1 cm stubble with tissue placed into a paper bag for future preparation. Clipping date and phenological growth stage was recorded for all grass cultivars at each clipping period.

All samples were oven dried at 60 degrees Celsius, ground through a 1 mm screen in a Wiley mill, and analyzed for dry matter, ash, CP, ADF, and NDF at the North Dakota State University, Animal and Range Sciences nutritional laboratory. Dry matter, ash, and ADF were determined following standardized procedures (AOAC 1990), NDF using procedures described by Robertson and Van Soest (1982), and CP using the Kjeldahl Auto System II (AOAC 1990).

Data will be analyzed to determine differences at the 0.10 percentile ($P<0.1$) between time periods and grass species cultivars. Analysis comparing differences in nutrient quality and forage production between time periods will be conducted using one-way analysis of variances as performed using Statistical Procedures for Social Sciences (1994). Analysis comparing differences in nutrient quality and herbage production between grass cultivars for each time period will be conducted using least square deviations as performed using Statistical Procedures for Social Sciences (1994).

Results and Discussions

The warm-season grass species differed in amount of forage production, timing of peak production, and levels of nutrient content. The results will be discussed in two sections, forage production and nutritional quality.

Forage Production

Although 13 warm-season grasses were selected for this trial in Pierre, 11 were tested for herbage production potential due to a loss in viable stands of Sand bluestem (Goldstrike and Garden). Herbage production was calculated by grass species. Herbage production alone should not be used to determine which grass species is a better choice for planting. Date of peak production (Table 2) and amount of time it remains at peak production (data not shown) must be looked at to best analyze a specific use of a grass species.

Table 2. Peak productivity (lb/ac) among 13 select warm-season grasses near Pierre, SD, 1999.

Grass Species (cultivar)	Peak Production 1999	Date of Peak Production
Big bluestem (Bison)	5953	mid-summer
Big bluestem (Sunnyview)	5973	mid-summer
Sand bluestem (Garden)	NA	NA
Sand bluestem (Goldstrike)	NA	NA
Sideoats grama (Butte)	679	late summer-early fall
Sideoats grama (Pierre)	1274	late summer-early fall
Prairie sandreed (Goshen)	2559	mid to late summer
Prairie sandreed (ND-95)	5279	mid to late summer
Switchgrass (Dacotah)	5956	mid summer
Switchgrass (Forestburg)	6879	early August
Little bluestem (Camper)	4081	early August
Indiangrass (Holt)	4523	early August

NA indicates data not available

Nutritional Quality

Sixteen warm-season grasses were analyzed for nutritional quality in 1999. To optimize livestock performance, ranchers would like the nutrient content of the grass to remain high throughout the grazing season or harvest grass stands for hay at optimum time for quality and production. These goals can be achieved if knowledge of nutrient content is determined and correlated with the production perimeters.

All grass cultivars showed a steady decline in crude protein (CP) content from June to early fall (Table 3). Species that maintained a higher state of CP included blue grama and prairie sandreed. Switchgrass declined to the lowest levels among the species. The phenological stage contrast between cultivars of the same species indicated nutritional differences. Big bluestem (Sunnyview) maintained a vegetative state throughout the study; therefore, it tested slightly higher CP levels than big bluestem (Bison). All grass species initially met the minimum nutrient requirements of a 1200 lb lactating cow, but dropped below requirements in mid-summer.

When reviewing the nutritional quality results of these warm-season grasses, quality can only be assessed for hay quality and not actual grazing quality. Livestock can selectively graze for higher quality than shown in this data; however, hay quality should be accurate since clipping was conducted similar to a haying operation. Comparison among grass species can be conducted and selection for grazing or haying since all grass species were collected and analyzed the same.

Table 3. Crude protein (%) content by date for selected warm-season grasses in Hettinger, ND and Pierre, SD.

Plant Species	6/21	7/12	8/4	8/23	9/14	10/5
			Date			
HETTINGER, ND						
Big bluestem (Bison)	13.27	9.97	7.79	6.59	5.90	3.41
Big bluestem (Sunnyview)	14.95	10.36	7.55	9.05	7.88	5.41
Sand bluestem (Garden)	14.07	10.81	8.09	8.24	7.32	5.82
Sand bluestem (Goldstrike)	14.59	10.87	8.54	8.55	7.63	6.05
Blue grama (Bad River)	15.49	12.07	8.92	9.34	8.75	6.89
Blue grama (Willis)	15.99	12.51	9.22	9.94	9.12	7.46
Sideoats grama (Butte)	14.85	11.18	8.68	7.73	6.30	4.84
Sideoats grama (Pierre)	15.12	10.97	7.78	7.48	6.57	4.75
Prairie sandreed (Goshen)	13.53	10.80	7.99	7.92	8.74	7.48
Prairie sandreed (ND-95)	14.90	11.56	9.44	9.02	9.77	8.07
Switchgrass (Dacotah)	15.89	10.49	7.05	6.71	5.61	4.24
Switchgrass (Forestburg)	15.88	11.42	7.84	7.77	6.88	3.92
Little bluestem (Badlands)	13.73	10.75	6.50	5.60	6.56	5.24
Little bluestem (Camper)	14.18	10.60	7.95	8.20	6.89	6.67
Indiangrass (Holt)	13.46	10.35	8.18	7.89	7.14	6.21
Indiangrass (Tomahawk)	14.27	9.84	7.14	5.81	5.05	4.22
Average for all cultivars	14.64	10.91	8.04	7.87	7.26	5.67
PIERRE, SD						
Big bluestem (Bison)	9.58	5.95	5.24	3.85	3.64	3.38
Big bluestem (Sunnyview)	9.82	6.23	5.41	4.34	4.58	3.76
Sideoats grama (Butte)	12.09	8.83	7.48	6.42	7.41	7.28
Sideoats grama (Pierre)	11.06	9.02	6.75	5.51	6.45	5.87
Prairie sandreed (Goshen)	10.28	7.78	6.53	5.56	6.60	5.99
Prairie sandreed (ND-95)	10.46	7.72	6.07	4.96	6.23	5.50
Switchgrass (Dacotah)	8.31	5.17	4.17	2.83	3.27	2.29
Switchgrass (Forestburg)	11.16	6.74	4.95	4.20	3.47	2.95
Little bluestem (Camper)	8.94	6.25	5.22	4.41	4.43	4.25
Indiangrass (Holt)	11.05	6.42	5.58	4.88	5.13	5.03
Indiangrass (Tomahawk)	11.10	7.18	5.99	4.67	5.08	3.34
Average for all cultivars	10.35	7.03	5.76	4.69	5.12	4.51

Summary

It appears that forage production and nutrient content will differ between some of these warm-season grasses and even between cultivars of the same species. Grasses such as Prairie sandreed and Blue grama were able to maintain relatively high levels of crude protein throughout the growing season. However, grasses that produced the most biomass (i.e. Switchgrass) had the lower levels of crude protein. Phenological developmental differences between cultivars of big bluestem indicated an effect of morphology on nutritional characteristics. The least matured plants were most nutritious. A full report will be published at a later date showing mineral and statistical analysis for crude protein, ADF, and NDF among all grass species and cultivars.

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Effects of multi-species grazing on leafy spurge infested rangeland using twice-over rotation and seasonlong grazing treatments (A Four-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 richness, 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), seasonlong grazing treatments (SL), and non-use treatment (NU) on leafy spurge control and 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 1988) 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 and 1997 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 1996, 1997, and 1998 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 $inch^2$ (0.1 m^2) quadrats and each quadrat assigned a number. Ten 12 $inch^2$ 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 $inch^2$ (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 performance were analyzed using a general linear model (GLM) (SPSS 1999). A mean separation was performed using Tukey's Honesty Significant Difference when significant ($P<0.05$) 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 was analyzed using a non-parametric test (Krushal-Wallis Test) (SPSS 1999).

Results and Discussion

Leafy spurge stem density significantly decreased ($P\leq0.05$) on the SL grazed and SL NU after three grazing seasons, however, there was no change ($P>0.05$) within the TOR grazed and ungrazed treatments after three grazing seasons. Also after the third year of grazing results showed that leafy spurge stem densities were lower ($P<0.05$) on the SL grazed and SL ungrazed than the TOR grazed and TOR NU (Table 1).

Table 1. Leafy spurge stem densities on the seasonlong (SL) , twice-over rotation (TOR) grazing treatment, and ungrazed treatments (NU) (standard errors in parentheses) in 1996, 1997, and 1998.

Treatment	1996	1997	% change 1996 to 1997	1998	% change 1996 to 1998	1999	% change 1996 to 1999
			-------------------- # / 11 $inch^2$	--------------------			
SL[1]							
Grazed	14.4 (1.9)[ax]	12.5 (1.0)[ax]	***-13.2***	11.5 (1.5)[ax]	**-20.1**	5.7 (0.6)[bx]	**-60.4**
NU	14.7 (1.9)[ax]	14.9 (1.0)[ax]	+ 1.3	17.1 (1.3)[ax]	+16.3	10.4 (0.9)[bx]	-29.2
TOR[1]							
Grazed	13.2 (1.5)[axy]	15.9 (1.4)[ax]	*+20.5*	12.8 (1.1)[axy]	**- 3.0**	13.4 (1.4)[ay]	**+1.0**
NU	8.6 (1.3)[ay]	10.8 (1.2)[ax]	+25.6	9.2 (1.3)[ay]	+7.0	11.5 (0.7)[ay]	+33.7

[1] Years and treatments with the same letter within treatments are not significantly different ($P>0.05$).

These results followed similar trends found by Lym et al. (1997) comparing multi-species grazing with cattle and angora goats. They reported seasonlong grazing reduced leafy spurge stem density faster than rotational grazing, even in year two. Results of this study would support Lym et al. (1997) in that seasonlong grazing using a multi-species approach would reduce leafy spurge stem density faster than rotational grazing. In both treatments and years, there was evidence that sheep were removing the flowering parts of the plant and preventing most seed production by leafy spurge, which supports Barker's (1996) statement that sheep will remove the flowering parts of the plant and most seed production by mature leafy spurge plants.

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 forth grazing season, grass and grass-like degree of disappearance increased to 39% on the SL and 25% on the TOR on leafy spurge infested communities. In the third and forth year, degree of grass and grass-like species disappearance showed a slight increase again on leafy spurge communities compared to 1996 and 1997.

Cow average daily gain (ADG) was higher (P<0.05) on the TOR treatment in 1997 than 1996, 1998, and 1999. However, cow ADG was lower (P<0.05) in 1998 than 1996, 1997, and 1999. Calf ADG was similar (P>0.05) throughout the three grazing seasons, however, ADG significantly increased (P<0.05) during the forth grazing season. Steer ADG were significantly higher (P<0.05) in 1996 and 1999 than 1997 and 1998 grazing seasons (Table 2).

Ewe ADG on the TOR treatment was lower (P<0.05) in 1997, 1998, and 1999 compared to 1996, dropping from 0.32 lb/day in 1996 to 0.25 lb/day and 0.26 lb/day in 1997 and 1998, respectively. 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). Results also showed there was a significant decrease (P<0.05) in pounds gained from 1996 to 1997. When analysis ewe performance between treatments, ewe ADG was higher (P<0.05) on the TOR in 1996 and 1998 with no treatment differences (P>0.05) occurring in 1997.

Table 2. 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, and 1999.

Treatment & Livestock Class[1]	1996[2]	1997[2]	1998[2]	1999[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]
Calf	2.33 (0.03)[a]	2.32 (0.03)[a]	2.42 (0.03)[a]	2.64 (0.03)[b]
Ewe	0.32 (0.01)[a]	0.25 (0.01)[b]	0.26 (0.01)[b]	0.24 (0.01)[b]
SL				
Steer	1.99 (0.04)[x]	1.84 (0.03)[z]	1.54 (0.04)[y]	2.09 (0.04)[x]
Ewe	0.23 (0.03)[x]	0.28 (0.03)[yb]	0.22 (0.01)[x]	0.17 (0.01)[z]

[1] **Years with the same letter within each treatment are not significantly different (P>0.05).**

[2] **Sheep (ewe) treatments with the same letter within each year are not significantly different (P>0.05).**

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OUT OF SEASON REPRODUCTIVE POTENTIAL OF WESTERN WHITE FACED RAMBOUILLET TYPE SHEEP UNDER NORTH DAKOTA CONDITIONS

T. C. Faller , P. T. Berg

INTRODUCTION

The seasonal fertility of sheep continues to be a biological puzzle. Unlocking the puzzle offers much opportunity to the sheep industry. Many earlier studies indicate acceptable levels of success in getting sheep to conceive and lamb in non-traditional seasons, however, it usually has involved light control and or hormonal therapy. Many times there still has been some level of failure. Occasionally the level of management employed has confused the level of success of or predictability of out of season lambing schemes. The inability of sheep to consistently lamb according to chosen season severely restricts the development of a constant, dependable supply of lamb meat to consumers. If sheep were able to conceive consistently in April and subsequently lamb in mid to late September it would reduce necessity of quality facilities to maintain a breeding sheep operation under North Dakota climatic conditions . This production scheme would open opportunity to the most economically attractive markets for North Dakota producers as well. Similarly mature ewes involved in a fall lambing scheme would be available as leafy spurge grazers during typical summer months without the presence of lambs to reduce potential of predation. This would be extremely attractive insight of the level of problems associated with the presence of leafy spurge in North Dakota.

PROCEDURE

Starting in 1986, Rambouillet ewes were randomly mated to Rambouillet rams and evaluated in a lambing system that anticipated the ewes to lamb three times in a two year period. In the spring of 1992 the flock was closed and the ewes were being evaluated based on the anticipation of breeding in April with a July clean up mating. The ewes were exposed each time with a 51 day breeding period starting April 4 and July 15. Ram to ewe ratios were one ram to twenty ewes. This closed flock was able to maintain consistent breeding success in April of 80-90 percent of the mature ewes. Replacement ewes were selected randomly from the September born ewe lambs similar to the selection of replacement rams. Poor growth or structurally incorrect individuals were removed from the population prior to making random selections. A control set of similar background ewes mated in November for April lambing has been maintained for the duration of the trials. Replacement ewes were exposed their first time in July along with the mature ewe flock and then re-exposed the following April regardless if they had conceived in the previous July. Ewes that did not maintain a lambing sequence that included every twelve month period starting with their first anticipated lambing time were eliminated from the flock.

In the fall of 1997 one hundred May born ewe lambs of similar wool grade and structural size were selected from a commercial sheep operation in Wyoming. The purpose was to compare breeding success when subjected to the exact same breeding strategy as the one hundred ewe lambs selected from the September born closed flock ewes. Similar selections were made in the fall of 1998 and 1999 with the same intent. Rams from outside flocks were also purchased each year to service a 2x2 factorial design that included closed flock ewes mated to closed flock rams, closed flock ewes mated to purchased rams, purchased ewes mated to closed flock rams and purchased ewes mated to purchased rams. Ram to ewe ratios were maintained to be similar for all breeding groups. All ewes included in the project will be weighed and condition scored annually in the month of April. A five point condition scoring system will be employed with 1 being emaciated and 5 being obese. Routine performance measures will be recorded for the duration of the studies. A strict regimen of isolation of ewes from rams will be maintained other than during the desired mating periods to take advantage of any positive effects of the presence of the ram in enhancing the onset of estrus. Similar data will be collected for the original closed ewe flock that originated in 1986.

RESULTS AND DISCUSSION

(Progress Report)

Table 1 indicates performance of the mature brood ewe flock that has been maintained as a closed fall lambing flock since 1986. All ewes were exposed to mate in April with clean-up mating in July-August. Table 1 indicates success of mating naturally without light control or hormonal therapy. Success would be categorized to be quite similar to seasonal fall mating for spring lambing.

Table 1 1999 Mature Flock Fall Lambing Performance

Birth Year of Ewes	1993	1994	1995	1996
Ewes Exposed	55	56	62	96
Ewes Lambing	55	53	60	87
Percent Bred to Fall Lamb	100	95	97	91

Table 2 indicates ewe body weights and condition scores for ewes exposed to lamb their first time in the fall . These measures would represent purchased ewes at 22 months of age and those from the closed flock being 17 months of age at breeding time in April. The data would indicate that the purchased ewes are very similar to the ewe flock that has been selected for fall lambing.

Table 2 Yearling ewe April Body Weights and Condition Scores

	Closed flock ewes	Purchased ewes
Shorn Ewe Body Weights (lbs)	113.2	113.6
Ewe Body Condition Scores	2.64	2.72

Table 3 indicates reproductive performance of the four breeding schemes described in the procedure . Numbers of ewes available at time of breeding were reduced from the original one hundred closed flock ewes and one hundred purchased ewes because of predation, loss of ear tags and other natural causes. Early indications are that the purchased ewes and rams performed at a level higher than anticipated for first exposure for fall lambing. Initially there appears to be a positive influence when using closed flock rams on purchased ewes.

Table 3 1999 Fall Lambing Performance of Purchased vs Closed Flocks

Closed Ewes x Closed Rams	
Ewes exposed	42
Ewes Pregnant	33
Fall Breeding Percent	79
Closed Ewes x Purch Rams	
Ewes Exposed	43
Ewes Pregnant	28
Fall Breeding Percent	65
Purch. Ewes x Closed Rams	
Ewes Exposed	43
Ewes Pregnant	33
Fall Breeding Percent	72
Purch.Ewes x Purch Rams	
Ewes Exposed	44
Ewes Pregnant	23
Fall Breeding Percent	52

Summary

This being the first year of a multiple year trial no attempt was made to analyze the data until year two and year three animals have been factored into the breeding scheme. It will be especially important to evaluate year two through four and to see if the purchased ewes breeding performance improves at similar rates as closed flock individuals as they mature in the system. They will continue to be measured as a comparison to the base closed flock.

EASY SHEEP

T. C. Faller, D. J. Nudell, J. D. Dahl

Introduction

The availability of labor on the average North Dakota farm has declined. Smaller family size and a greater dependence on off-farm jobs, combined with increased mobility allowing family members more opportunities in educational, social and recreational events have dramatically reduced the available labor supply for traditional animal agriculture. Currently minimum wage off-farm jobs are perceived as competitive with smaller supplemental income on-farm enterprises. Reduced family labor has forced farm operations to become more specialized and often animal production enterprises have been eliminated. This in part explains declines in some of the more labor intensive supplemental enterprises on North Dakota farms including poultry, dairy, swine, and sheep production.

The Hettinger Research Extension Center (HREC) has recently collected data that suggested some economic advantage for pasture lambing systems as compared to more traditional rearing systems. Traditional animal husbandry favors a very strong connection between the caretaker and the animal. Reduced labor systems of sheep production may be more acceptable to todays farm family life styles. The reduced care levels afforded to the animals may not be acceptable to the caretaker. Increasing sheep numbers because of new flocks based on reduced input sheep production may assist the North Dakota sheep industry to rebuild to satisfactory numbers. Regrowth of the industry would help support necessary industry infrastructure.

In the spring of 1999 the HREC provided three small flocks of pregnant ewes to three cooperators. One goal was to collect information on producer responses to pasture rearing of sheep with reduced inputs and labor. Additionally we wished to see if actual production results on cooperators farms matched those achieved using this system of management at the HREC. Finally we will compare potential financial results of the EZSheep system to more traditional systems of production.

Procedure

On April 1, 1999 a flock of five and six year old Montadale x Rambouillet ewes was ultra-sounded for pregnancy at the HREC and seventy six head were found to be pregnant. On April 15, 1999 the ewes were delivered to each cooperator based on their capacity to provide resources for sheep. Fifteen head was delivered to a first time producer at Fort Yates , ND, thirty head were delivered to an experienced sheep producer at Walcott, ND, and thirty one head went to a dairy producer at Towner, ND. These three producers represented a very diverse sample of farms. The ewes were bred to lamb between the period of May 15 and June 18. The lambs and ewes were picked up, counted and weighed between September 24 and October 4. The lambs would have averaged approximately one hundred twenty days of age.

Producer responsibilities included; ear-tagging and counting the lambs and ewes at the end of the anticipated lambing period, documenting what happened on the farm as it happened, and documenting their personal feelings throughout the course of the project. At the end of the lambing period and again at the conclusion of the summer season the cooperators were asked to fill out a short survey detailing what had happened and how they felt about the project. Producers were afforded the opportunity to participate a second year. The survey also asked if they would participate a second year and why or why not.

An Economic Model of EZSheep results

Three cooperators tested the EZSheep system on their farms in the summer of 1999. The results of their lambing seasons were combined and an economic model (Sheepbud) was constructed to compare the projected financial returns from the EZSheep cooperators to more traditional sheep production systems in North Dakota.

Table 1 shows the actual production results achieved by the EZSheep cooperators, their average results and an estimated set of North Dakota results under more typical production scenarios. In the comparison analysis, EZSheep average production results to weaning were carried through the model to an expected sell weight of 125 pounds. The North Dakota comparison flock modeled a typical winter lambing flock with early weaning and lambs going directly to feed till they reached a 125 pound market weight.

Table 1. Flock summaries.

Flock Number	Wahpeton	Towner	Fort Yates	EZ Ave.	North Dakota
No. Of Ewes	30	31	15	76	100
Ewes Died	1	2	2	5	4
% Ewe Death	3.3	6.5	13	6	4
Lambs Weaned	39	29	20	88	130
% Lamb Crop	130	97	133	116	130
Lamb Wean Wt	2669	2610	1545	6824	5850
Lamb Sell Wt				11000	16250
Ave. Lamb Wt.	68	90	77	78	45
# Lamb/Ewe	89	84	103		

In a comparison of economic results of EZSheep to a more traditional lambing scenario a number of assumptions were used. They are:

- All lambs sold for $75/cwt at 125 pounds
- Wool is assumed to be 8 lb per ewe and is valued at $0.25/lb.
- Replacement rate is 15 % and all replacements are purchased at $110
- Ewe death rate is 4% for traditional and 6% for EZ
- Traditional scenario assumed a barn valued at $5000
- EZ assumed winter shelter to be a windbreak valued at $500
- Equipment value is $1000 for traditional and $500 for EZ
- Traditional scenario markets 130 % lamb crop
- EZSheep scenario markets 116 % lamb crop (average of 3 cooperators)
- Marketing and trucking expense per head is the same in both scenarios
- Traditional scenario includes 25 lb creep feed per lamb and slightly higher vet expense
- Fuel and utilities expense are 2.5 times higher in winter lambing scenario
- Labor and management time is valued at $10 per hour in both scenarios
- Labor and management time is 3 hours per ewe in winter and 1 hour per ewe in EZ
- Winter flock total assets are valued at $17,750 (includes value of ewes)
- EZ flock total assets are valued at $12,500 (includes value of ewes)
- Both scenarios assume $5500 debt on ewes (on % basis EZSheep carries higher debt)
- Return on Assets is calculated as Net Cash Income + interest paid - value of labor and mgmt / total asset value

The traditional winter lambing scenario shows a positive net cash flow of $6.75. However the increased labor and higher investment means that return on assets used in the sheep operation is a negative 10%. EZSheep shows a higher net cash flow of $17.13. This is due largely to decreased feed costs for both ewes and lambs. In addition return on assets is positive at 8.7%. The positive return on assets occurs because the labor needs and total assets used in EZSheep are considerably smaller than in traditional systems.

Table 2. Financial Results of Comparison

	Net Return Flock	Net Ewe	Interest Paid	Labor Charge	Asset Value	Return on Assets
EZSheep	$1,302	$17.13	$550.00	$760.00	$12,500.00	8.7%
North Dakota	$675	$6.75	$550.00	$3,000.00	$17,750.00	-10%

Results of Cooperators Surveys (Lambing and Weaning Time)

A questionnaire was sent to each cooperator after lambing and at weaning time. The questionnaires asked animal production questions and questions on the concept of EZSheep. Questions included; In your estimation what was the major cause of lamb losses?, what was the major causes of any losses of ewes?, were there any predation incidences?, what are your feelings on this system of animal production?, and what changes would you make to enhance this form of low input/labor livestock production?

In the lambing time survey cooperators indicated the primary reason for lamb and ewe losses were the condition of ewe at lambing and the size of the lambs. One of the cooperators experienced few difficulties with the ewes lambing, however, another cooperator felt that if he had kept a better watch on the ewe's during lambing he would have saved a few lambs due to their size. All of the cooperators but one felt that this idea was a good way to cut labor and cost during lambing but changes had to be made in ewe and ram selection to produce smaller lambs at birth. Two of the three cooperators said they would be willing to cooperate again in 2000, however, they suggested that the selection of ewes for udder size and breed type may provide better lambing success. All cooperators felt that predation was going to be a problem with this method of animal production.

A questionnaire was also distributed during weaning time and at this time producer felt that the number one reason for losses in the flock from lambing to weaning was ewe condition and udder size (large teats make it hard for lambs to drink and they are starving). The cooperators suggested that a different breed, or selection of rams for smaller lambs may produce better results. Cooperators at this time still thought that this method of animal production was a viable way to go to reduce labor and cost. Two of the three cooperators were willing to give this concept another try next year. One cooperator was not comfortable with this system of livestock management.

The age of the ewes in this study was 5 and 6 years of age. This was identified as one of the potential causes for some of the difficulties experienced during lambing and after lambing. The two producers who agreed to participate will receive the same flock of ewes next year.

Conclusion

EZSheep has potential to be an profitable management system for sheep production in North Dakota. It may be an especially valuable management strategy for new operations that do not have existing facilities. EZSheep may not be for everyone. The cooperator who declined to participate next year appeared to us to want to provide a more nurturing environment for animals in her care than EZSheep provides. This points out quite clearly that this type of system is not for everyone. However, the potential return on asset rates suggested by the scenarios presented here, would suggest that sheep producers take a hard look at the results of the EZSheep work.

PRODUCER RESPONSE TO THE SQUARE BAGGER

T. C. Faller

Introduction

The Hettinger Research Extension Center (HREC) purchased a square bagger in the fall of 1998 for use of the HREC. It was apparent that as the industry was being required to make relatively hasty switches from both the conventional tube type sacker and from jute packs to film packs that there was considerable producer resistance to change. Producer concern was magnified by the reduced market price for raw wool as a commodity. There had been indications in the past that this change was coming but when attempts were made to change the packaging of raw wool it always reverted back to the old standard and many producers assumed that the same would happen once again. Very little research and development had been done in the area of film packs previously and rapid paced development had to be deployed to meet the needs of spring shearing for the year 1999. The HREC made their bagger available to a number of producers in the area for the sake of collecting some preliminary response to the equipment and the process. Producers also paid an upkeep fee for the use of the equipment.

Procedure

Producers were able to pick up the equipment at the HREC or arrange for its use through a local shearing crew. Producers paid their fees directly to the HREC or through their shearer. They were required to fill out a short survey as a contingency of use. Head count was included on the survey form to see if there was any difference in the response based on size of operation. The survey consisted of four main questions with the opportunity to make comments relative to each question. The scale for the questions was 1-10 with 1 being good or acceptable and 10 being unacceptable. An overall comment section was also made available to producers to respond in any way that they wished.

Summary

Wool from 5,699 head of sheep was packaged as resources of this survey. Approximately 120 bags of raw wool were packaged in film packs by the equipment. Producers were very cooperative in responding to the questions posed and many offered comments. Some of the questions were not scored by producers due to a number of reasons, usually because it did not apply to their operation. The intent of this collection of data was to provide producers some level of insight on the application of this new technology and how other producers have responded to it.

Survey

1. Question number one was **Rate ease of use of square bagger as compared to conventional round baggers.** Average numerical response was 3.9

   Comments:
   a. Easier
   b. Does a nice job
   c. Bags are easier to close
   d. Easier because you don't have to change bags as often
   e. Relatively easy to use, just throw in fleece and operate
   f. Faster

2. Question number two was **Rate durability of film packs as compared to round jute bags.** Average numerical response was 4.56

   Comments:
   a. Getting better as improvements have been made in size and durability
   b. Not as durable
   c. Did not use (used old poly packs)
   d. If they are put in properly they didn't tear
   e. Tears out at corners too easily
   f. They are a lot stronger
   g. Holes in plastic tend to enlarge
   h. More durable than jute

3. Question number three was **Rate ease of handling and storage on the ranch for square film packs**. Average numerical response was 3.63

   Comments:
   a. Easy to store
   b. Storage is simple but you need a loader to handle
   c. Not as easy to handle because of weight and not able to roll them
   e. Not applicable
   f. Easier to stack
   g. Easy to transport

4. Question number four **Rate the process and impact on your operation.** Average numerical response was 4.4

   Comments:
   a. Not much impact other than increase costs
   b. Costs not commensurate with returns
   c. Did not use as many bags

Comments: (question number four continued)
d. Works really well except for trying to get the hooks in the top
e. Very modern and dependable but may not be practical for small operations
f. Less bulk

Over all comments:
a. Too expensive to own
b. I was impressed with the machine but cost prohibitive for the small producer
c. Should have a pressure gauge on the hydraulics to help judge when the bag is full
d. The producer is forced to package wool differently without any extra money returned
e. Worked fairly well
f. Plug fouled out, some bags ripped in the corner, bags seemed a little small, but they handled more easily, thought it worked excellently
g. It's not bad but I hate not being able to make my own choice (square vs round)
h. Worked fine

*** Similar answers were not recorded more than once as the data was not to be statistically analyzed.**

Summary and Conclusions

Response to this change in technology was not difficult for producers to accept and as they worked with the equipment they indicated general acceptance. Problems with the equipment centered mostly on lack of good measures of fullness of the bag. **Note:** A small flimsy scale that came as a part of the bagger was removed by the HREC prior to any producers having a chance to evaluate it. A more dependable model may have to be added. Problems with materials centered on bag strength and size and there seemed to be steady improvement throughout the shearing season. **Conclusion: Changing to square baggers and film packs should not negatively impact producers with sizeable operations, however, small producers and collective marketing structures (such as wool pools) could be impacted and the industry should work to assist these groups.**

EKRE PROJECT - 1999 EWE FLOCK

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PRODUCTION GOALS OF THE EKRE EWE FLOCK

Flock Size: 125 ewes
Stocking Rate: 1 ewe per 5 acres
Ewe Type:

- ★Highly fertile - drop 200% lamb crop.
- ★Heavy milkers - be able to raise twins.
- ★Moderate frame size 150 - 170 lbs.; lower feed requirements than a larger 200 - 250# ewe; can run more ewes on given land area.
- ★Utilize speckled face ewes.
- ★Increase heterosis or hybrid vigor.
- ★Increase fertility, livability in lambs and milking ability.

Labor Inputs:

- ★Low inputs during grazing & maintenance periods (early spring - late fall).
- ★Highest requirements at lambing and lactation periods.

ECONOMIC SUMMARY FOR 1999

1999 FLOCK OF 76 EWES
Ewes lambed in Feb-March; Lamb Drop = 178%; Death Loss = 8.9% 135 lambs born; 123 lambs weaned

1998 FLOCK OF 50 EWES
Ewes lambed in Feb-March; Lamb Drop = 178%; Death Loss = 12.4% 89 lambs born; 78 lambs weaned

Feed Expenses by the ewes:
Nov/May 15 - Beet tailings, hay, and grain fed. **200 days TOTAL ~ $25 /ewe**
May 15/Oct - Grazing on Ekre Property (**value versus 165 days @ 4 lbs hay/ day =$19.80**)

Lamb Marketing Income - 1999 - August

83 lambs marketed at $0.80/lb; averaged 135 lbs. Gross $8964 ($108/head)
40 ewe lambs retained at a market value of $100/head. Gross value $4000.
Total gross $12,894 ($105.40/head) or **$170.58/ewe**.

In 1998, lambs grossed $8553.36 ($112.55/head) or **$171.07/ewe**.

Lamb feed costs til mid August

Lambs conversions were 4.4 pounds of feed per pound of gain for a total of ~ 375 pounds of feed per lamb (weaning-50 lbs to 135 lbs). The ration cost approximately 5 cents a pound. Total feed cost per lamb was $18.75. (At a feed cost of 6 cents, the feed cost/lamb would have been $22.50)

Total lamb feed costs - $2,306.25 (@5 cents) or **$30.35/ewe**.
Total lamb feed costs - $2,767.50 (@6 cents) or **$36.41/ewe**.

"Positioning Lamb Producers to be Competitive in the U.S. Market"

Jeff Held, SDSU; Roger Haugen, NDSU; & Paul Berg, NDSU

Lamb Growth Efficiency and Optimum Finished Weight

Jeff Held, Extension Sheep Specialist, SDSU

Introduction

In the sheep enterprise, lamb sales account for more than 90 percent of gross revenue. Most analyses indicate profitable sheep production is dependent on market prices, pounds of lamb weaned or sold per ewe exposed and the unit cost of production. Producers have little control annually over selling price for their lambs, but they do control production efficiency. Ewe productivity and ewe/lamb feed cost containment are important parameters for all types of flock management systems whether a feeder lamb or finished lamb production emphasis. It is important to excel in each area independent of the type of operation. The feeder lamb operation success is directly linked to economic efficiency in producing pounds of weaned lamb per unit ewe cost. This is also true for the lamb to finish operation but in addition the practice of finishing lambs should be considered an independent enterprise. The economic efficiencies in lamb finishing are measured by the cost to produce a pound of body weight. Essentially producers should evaluate production efficiencies of the ewe and lamb independently and on a flock basis to evaluate these profit centers.

Market Price Trends

Historically finished live lamb price has peaked prior to the Easter holiday with a slow but steady decline through late summer. First and fourth quarter price trends with little or any sharp price shifts. Even though the price was difficult to determine the trend and peak price period was predictable. Producers in the farm flock areas had used this information to design flock management and marketing decisions.

However the dynamics of lamb marketing have changed in the 90's, price trends have moved away from the traditional shape. Peak annual finished lamb prices have occurred post-Easter, in May or June rather than coincide with a structured demand period it is dependent on a short supply. As the supply of "old crop" feedlot lambs decline processors rely on "native" new crop lambs to make up the supply. Reductions in the farm flock ewe base during this decade have created marketing trends with up movement well into the summer months.

Many factors have contributed to the more recent finished lamb market price trends. Adequate feedlot lambs are carried farther into the calendar and at much heavier live weights than in the past. Live lamb market weight continues to increase since 1975 the U.S. live lamb market weight has increased more than 1 pound per year (Table 1). There appears to be little economic opposition to extremely heavy lambs.

Table 1. U.S. Live Lamb Finished Weight

Year	Live Lamb Weight (lb)
1975	104
1985	115
1995	126
1998	132

Farm Flock Profit Centers

Over the past decade producers have needed to look at more than peak lamb price trends to establish a flock marketing management plan. Live lamb price trends have been difficult to predict and packer demands for heavier finished lamb have changed several characteristics in the intensive lamb to finish farm flock. With the sporadic nature of market conditions progressive producers have become more focused on lowering production costs by improving ewe productivity. These management changes include the use of prolific breed genetics in cross breeding, shifting to later lambing dates to improve lambing percent and more recently greater use of forage based resources. Improved ewe efficiencies can reduce input costs to withstand periods of low lamb prices and take advantage of high profit periods.

Heavier lamb market weight is an opportunity to increase the pounds of lamb marketed and gross return per ewe. With ever-increasing finished market weights evaluating flock genetics for optimum lamb economic growth efficiencies becomes a higher priority. Simply adding more pounds into existing flock genetics may be inefficient and fail to increase net return per ewe. Lamb economic growth efficiency is often over looked compared to the effort placed on improving ewe production efficiencies.

Farm Flock Ewe Base

Many different breed combinations can be found in farm flock operations. Wide variation is evident in the mix of ewe flock genetics, ranging from small to medium framed ewes which excel in prolificacy or wool quality to extremely large framed terminal breed based ewes which have superior growth traits as featured assets. Smaller framed ewes have lower annual feed costs compared to the large framed type based on maintenance feed requirements.

Often the question is raised, "What kind of ewe is best for my operation"? Anyone who has given thought to this question would respond with the following: a low maintenance cost, highly productive ewe with superior mothering ability where by she successfully lambs, and rears all lambs born with out any assistance. Interestingly little is mentioned whether the offspring can excel in growth efficiency to the industry average finished weight or higher. Ewe productivity and offspring growth efficiency are linked economic management desires in the farm flock.

Lamb Finished Weight-Body Composition Relationship to Frame Size

The dynamics in the sheep industry continue to trend toward heavier finished lambs. It requires a larger-framed lamb to reach heavier weights with the same or improved growth efficiencies compared smaller framed genetics. Researchers at the University of California-Davis have shown that parental frame size can be used to predict offspring finished weight. As illustrated in Figure 1 Bradford and coworkers at the University of California-Davis developed a model to predict finished lamb body weight based on ewe body weight information from dam and sire breeds. All predicted lamb weights are at constant degree of finish corresponding to a Yield[a] Grade 2 carcass, fat measurement at 0.17 inches (12-13th rib fat). Using Figure 1, a 116 pound lamb would be expected when the ewe breed is 160 pounds (left column) and the dam of the terminal sire breed is 200 pounds (upper row). The predicted lamb weight is determined using the average weight of the ewes (160lb+200lb/2=180lb) multiplied by 64 percent of mature body size (180lbx0.64=116lb). This research shows that predicting the weight at which a lamb reaches a specific level of fat cover can be estimated based on objective measure for parental frame size. This information can be useful to set goals for a flock market plan and evaluating lamb growth potential in a flock ewe base.

Fig. 1 Predicting Target Market Weight

	Sire Breed Mature Ewe Weight (lb)					
Ewe Breed Mature WT	**220**	**200**	**180**	**160**	**140**	**120**
230	144	138	132	126	120	114
220	141	135	129	123	117	111
210	138	132	126	120	114	108
200	135	129	123	117	111	105
190	131	125	119	113	107	101
180	128	122	116	110	104	98
170	125	119	113	107	101	95
160	122	116	110	104	98	92
150	119	113	107	101	95	89
140	115	109	103	97	91	85
130	112	106	100	94	88	82
120	109	103	97	91	85	79
110	106	100	94	88	82	76

Researchers at Colorado State University studied small, medium and large framed lambs to target finished weights. Carcass data was collected to correlate degree of finish with final weight. Large framed lambs were heavier than medium or small framed lambs, medium heavier than small framed lambs when compared at similar degrees of finish. From these data researchers developed a model to predict the finished weight and associated degree of finish (fat depth at 12-13th rib) by frame size. Table 2 shows the prediction model for wether lambs using these data.

Table 2. Projected Target Market Weights

	Fat Thickness		(12-13th rib)
	.15	.25	.35
FRAME SIZE		WETHERS	
Small	92	116	140
Medium	97	126	154
Large	109	140	170

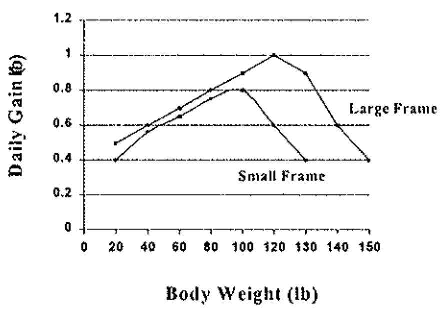
[a] Yield Grades and Quality Grades for Lamb Carcasses will be discussed in later section.

An extrapolation of these data to the Bradford model leads to a classification of ewe frame size based on body weight: 140 pounds or less - small framed, 140 to 170 pounds - medium framed and more than 170 pounds - large framed. Offspring from mating ewes and rams within a frame size would probably be more predictable than matching individuals from the extremes in frame size. Even though these class breaks could be argued the fact remains that a lamb finished weight-body composition relationship is inherent on parental frame-size and furthermore not easily altered by changes in nutritional or other management modification.

Lamb Growth Efficiency

Larger framed lambs are expected to be leaner than smaller framed lambs when compared at equal weight. Animal growth performance, expressed as average daily gain, favors a leaner animal since the conversion of feed to lean weight gain is higher than for fat weight gain. Therefore average daily gain for the larger framed leaner type of lamb would be higher at a constant weight comparison (Figure 2).

Fig. 2 AVERAGE DAILY GAIN



Daily feed intake increases with higher weights although as a percent of body weight intake is nearly constant at 4 percent throughout growth. Feed efficiency, expressed as the pounds of feed to add a pound of body weight, declines with heavier weights and higher levels of body fat.

When feed efficiency declines sufficiently the cost of the feed consumed to add a pound of gain can exceed the value of the next pound gained. At this point the animal has reached the optimum economic market weight for the animal. Using the economic expression for feed efficiency, cost of gain, the optimum economic market weight for lambs can be identified. It is important to understand cost of gain, how to calculate and how to use it. The next section provides a review on cost of gain concepts:

Cost of Gain – An Economic Expression for Feed Efficiency in Finishing Lambs

To express cost of gain (CG) several equations are offered:

Expression 1

= cents/pound of gain

Expression 2

$$= \frac{\text{(feed cost (cents/lb))} * \text{((daily feed intake lb) x (days on feed)))}}{\text{Pounds of gain}}$$

Expression 3

$$= \frac{\text{(feed cost (cents/lb))} * \text{(daily feed intake, lb)}}{\text{Average daily gain (ADG)}}$$

Expression 4

= feed cost (cents/lb)* feed efficiency (pounds of feed/pound of gain)

The most useful economic management assessment tool in lamb feeding is cost of gain (CG). The average cost of gain, reported as cents/pound of gain, is the most common expression in closeout information for an entire feeding period. However using average CG is historical information and offers little when evaluating feeding practices or determine optimum economic finished weight. Using expression 2 or 3 it becomes clear that altering feed cost, feed intake or growth performance can affect CG. Does a higher ration cost equate to higher cost of gain, not necessarily so! It depends on intake or performance responses. In contrast, a low cost ration that retards growth performance can result in higher CG. Cost of gain can be determined on a daily basis, weekly, or any other period. Expression 4 is probably the straightest forward, since it is feed efficiency multiplied by the ration cost. When feed efficiency declines, more pounds of feed per pound of gain, the cost of gain increases.

Using Cost of Gain to Explain Growth Efficiencies

Cost of gain trends higher with increasing lamb weight. The lowest cost of gain is usually during early growth when lambs are lightest and leaner. The post-weaned 60 to 90 pound lamb will perform especially well on a cost of gain analysis. Interestingly the lowest cost of gain in the feeding period occurs at or before peak average daily gain. Creep and growing diets must provide adequate nutrients to take full advantage of growth efficiencies. Lamb frame size has less impact on cost of gain up to 90 pounds since body composition is similar.

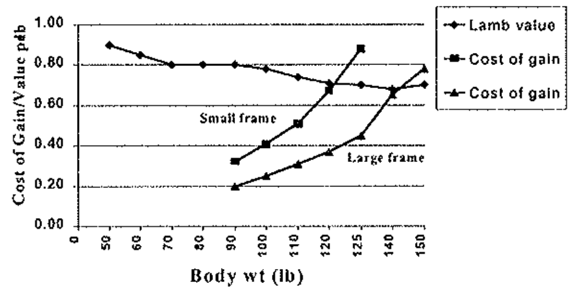
As animals get heavier it takes more feed to gain a pound of body weight since the gain contains more fat and less muscle than at a lighter less mature status of growth. Since feed intake continues to climb at higher weights and average daily gain falls, cost of gain can rise sharply. Frame size differences become more significant at heavier weights since the cost of gain will rise at a lighter weight in the small framed versus larger framed lambs.

Using Cost of Gain to Determine Optimum Economic Lamb Finished Weight

Figure 3, "Lamb Profit Potential" was developed to help illustrate how cost of gain can be used to maximize lamb return in the finishing period by identifying the optimum economic finished weight. The graph presents comparisons with two costs of gain curves and a live lamb market price line. Plotted is the cost of gain for small and large framed lambs, and the live price for lambs adjusted for a typical weight slide. To interpret these comparisons, at any weight where cost of gain is below the price line the last pound gained was profitable; when cost of gain intersects the price line the last pound gained was a breakeven, above the price line at a loss.

The breakeven for the small framed lamb is set at 120 pounds and 140 pounds for the large framed. The difference between a cost of gain line and market price is the profit at a given weight. It's important to recognize that profit is not determined by the intersect weight for each frame type. Instead it is the additive positive differential between the value and cost of the pounds gained. For example at 100 pounds the live lamb value is $0.80 per pound, the cost of a pound of gain is $0.40 for small framed and $0.25 for large framed. The differential is $.40 ($0.80-0.40) for the small framed and $0.55 ($0.80-0.25) for the large framed. The differential at lighter weights is greater and the respective frame type cost of gain intersects live lamb value where they are equal thus the differential is zero. Average daily gain drives progressively declines at heavier weights until cost of gain more than any other variable including feed cost. Where the cost of gain lines intersect market value the average daily gain was approximately 0.5. The economic advantage for the large framed lamb is two fold, the differential is greater at a given weight and a positive differential can be found at a higher weight.

Fig. 3 LAMB PROFIT POTENTIAL



Generally during the finishing period when average daily gain falls to 0.5 pounds per day feed efficiency will be at or even exceed 10 pounds of feed per pound of gain. Selecting genetics, which excel in feedlot performance provides the producer an opportunity to reap the benefits when feed costs are low and market prices high since cost of gain would indicate feeding to higher weights at a profit. Most importantly having superior growth efficiency built into the flock offers the producer a competitive advantage when feed prices are high or market prices low since the optimum economic finished weight would be lower.

Over the past twenty years numerous lamb studies have been conducted to evaluate growth efficiency and economic return. Often critical information and data is not available to clearly demonstrate the relationships between frame size and body composition in predicting an optimum economic finished weight. However a study at the University of Idaho by Dahmen illustrated that optimum economic live lamb finished weight is dependent on frame size and body composition.
In this study sixty-four large framed (175 lb crossbred black ewes mated to 300 plus pound Suffolk rams) twin born black-faced cross lambs with an initial weight of 73 pounds were split equally into 4 finishing groups with projected finished weights of 110, 120, 130 and 140 pounds. At the start of the trial age of lamb was

100 days, the length of the trial was 84 days. All lambs were individually penned to record feed intake. A pelleted forage based ration, moderate for energy density, was offered through self-feeders.

Growth performance across the weights was from 0.97 pounds for the 110lb-lamb treatment group to 0.81 pounds for the 140lb-treatment group. The decline was nearly linear from lightest to heaviest treatment groups. The respective carcass fat cover measurements, from 110 through 140-pound groups were 0.13 in. (Yield Grade 1), 0.20 in. (Yield Grade 2), 0.30 in. (Yield Grade 3) and 0.34 in. (nearly a Yield Grade 4). Their income analyses showed the greatest return above cost was for the 110 and 120 weight lambs. These lambs were yield grade 2's or lower. Conclusions included the following statement "changes in feed cost or changing market prices could change optimum economic slaughter weight slightly but because of the decline in feeding efficiency at heavier weight it is not likely that feeding above 120 pounds would be profitable except in unusual circumstances".

Feed efficiency was determined at 2-week intervals over the 84-d feeding trial. Through day 56 the feed efficiency averaged 6 to 8 pounds of feed per pound of gain. In the 70 and 84-d feeding periods the value was over 13 pounds of feed per pound of gain. The sharp decline in feed efficiency after day 56 corresponds to finished weights beyond 120 pounds. The impact of lower feed efficiency, thus higher cost of gain, on net return per lamb slaughter weight group is dramatic as shown in Figure 4.

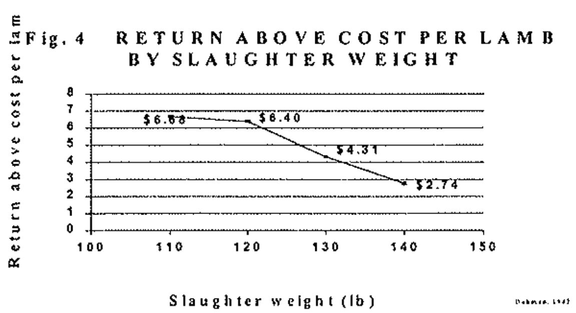


Fig. 4 RETURN ABOVE COST PER LAMB BY SLAUGHTER WEIGHT

The optimum net return occurred near 120 pounds in this study even though at heavier weights the lambs were profitable. Why? Essentially for every pound gained above 120 pounds the cost of gain was more than the value of the gain i.e. the profit accumulated up to 120 pounds was partially used to cover the loss for any additional weight gain. This scenario is similar to that described in the "Lamb Profit Potential" section earlier in this document. Evaluating profitability for these lambs from the beginning weight to 130 or 140 pounds would have masked the finished weight for optimum profit.

Summary

Heavier finish lamb marketing trends provide economic opportunity and have challenged management in the farm flock lamb to finish operation. Simply adding more weight to offspring from an existing genetic ewe frame size base may not necessarily increase optimum economic lamb feeding return, it could be reduced. The model by Bradford shows the impact of ewe frame size on the lamb weight-body composition relationship. Research has shown that optimum returns often coincide when lambs reach a carcass composition at a high yield grade 2 to low yield grade 3, approximately 0.25 inches fat cover. Feed efficiency often declines sharply beyond this degree of finish, mainly due to the reduced average daily gain. When feed efficiency reaches 10 pounds or more per pound of gain the average daily gain will approach 0.5, it can go lower. Using degree of finish or average daily gain benchmarks producers can indirectly determine the optimum economic finished weight. Directly determining cost of gain on a group of lambs during intervals in the feeding period would be ideal. Increasing flock frame size to push the optimum economic lamb finished weight higher must be evaluated with regard to negative impacts on ewe productivity and maintenance costs.

Yield Grades and Quality Grades for Lamb Carcasses

Roger Haugen, Extension Sheep Specialist and Paul Berg, Animal Scientist, NDSU

Lamb carcass grades when applied by a USDA meat grader must consist of a yield grade and a quality grade. Yield grades estimate the percentage of closely trimmed, boneless retail cuts from the leg, loin, rib and shoulder. Quality grades indicate the palatability or eating characteristics of lamb.

Evaluating lamb carcasses for USDA Yield and Quality Grades recognizes carcasses with traits that influence live animal and carcass value, and identifies breeding animals that produce lambs of superior carcass merit.

Yield Grades

Yield grades reflect the "quantity" of retail cuts that can be expected from a lamb carcass. Yield grades are 1, 2, 3, 4 and 5 with yield grade 1 being more desirable than a yield grade 5 in the amount of retail cuts from the leg, loin, rib and shoulder. Adjusted fat thickness of the carcass is the only factor used to determine lamb yield grades. In addition the kidney and pelvic fat must be removed from the carcass, leaving no more than one percent in the carcass.

Yield grades are a numerical representation of % cutability. Cutability is the percentage of carcass weight represented by the boneless and bone--in closely trimmed (0.1 inch) retail cuts from the leg, loin, rib and shoulder. Yield grades and their corresponding % cutability are presented in ***Table 1***.

Table 1. Percentage Cutability and USDA Yield Grade.

YG	% Cutability
1.0	51.0
1.5	50.35
2.0	49.7
2.5	49.05
3.0	48.4
3.5	47.75
4.0	47.1
4.5	46.45
5.0	45.8
5.9	45.15

Adjusted Fat Thickness: Adjusted fat thickness is the most important predictor of cutability and for simplicity in applying the grades is the only yield grade factor. Fat thickness is measured between the 12th and 13th ribs over both ribeyes at the midpoint of the ribeye.

The measurements are then averaged. However, the fat thickness measurement may be adjusted either up or down for unusually heavy or light fat deposits. Fat adjustments of .05 to .10 inch are typical. The amount of fat in the body wall, crotch, cod or udder, sirloin-loin juncture, shoulder and breast is considered in making fat adjustments. The body wall thickness measured from the inside of the rib to the outside fat at 4 inches below the ribeye provides a guideline for adjustments in fat thickness. ***Table 2*** provides typical body wall measurements for each yield grade for a 50 and a 75 pound carcass.

Yield Grade Calculation: Yield grades are calculated by using the following formula:
YG= 0.4 + (10 × adj. fat thickness)
For example, to calculate the yield grade for a carcass that has an adjusted fat thickness of .25 inch would be as follows: YG = 0.4 + (10 × .25)   **YG = 2.9**

Table 2. Typical Body Wall Measurements for different Yield Grades.

Yield Grade	Typical Body Wall Measurements	
	55 lbs Hot Carcass Wt	75 lbs Hot Carcass Wt
1	0.75	0.85
2	0.90	1.00
3	1.05	1.15
4	1.20	1.30
5	>1.20	>1.30

Leg Conformation Score

Leg conformation score is not used in yield grading but is an indicator of carcass muscling.

Leg scores are normally coded, such as:

15 = Prime +	**12 = Choice +**	**9 = Good +**
14 = Average Prime	**11 = Average Choice**	**8 = Average Good**
13 = Prime -	**10 = Choice -**	**7 = Good -**

Superior leg scores (higher number codes) are very wide and thick which should indicate a high lean to bone ratio. Narrow, angular legs (lower number codes) will have a lower proportion of edible meat to bone.

Ribeye Area

Although ribeye area is not a yield grade factor, ribeye size is important in evaluating the carcass merit of a lamb. Ribeye area is measured at the 12th rib by using a plastic grid or by tracing the eye on acetate paper and then using a grid or a compensating polar planimeter to determine the area. Only the large major ribeye muscle should be measured - do not count the small muscles adjacent to the ribeye muscle. Both ribeye muscles should be measured and the average reported. **Desirable Ribeye Standards** for various weight ranges can be calculated using the equation **1.4 + (0.02 × Hot Carcass Weight, lbs).**

Quality Grades

Quality grades indicate the expected eating satisfaction of lamb. USDA Lamb Quality Grades are based upon palatability indicating characteristics of the lean and carcass conformation. Conformation has no direct influence upon the eating quality. For quality grading purposes, there are three carcass classes - lamb, yearling mutton and mutton. There are four quality grades within each class. For lamb and yearling mutton the quality grades are Prime, Choice, Good and Utility.

Mutton carcasses are graded Choice, Good, Utility and Cull. The factors used in quality grading lamb carcasses are: 1) maturity, 2) lean quality and 3) carcass conformation.

Maturity: Maturity in lambs is determined by evaluating lean color and texture, rib bones and break joints. Carcasses are classified as lamb (young lamb or older lamb), yearling mutton and mutton. Lamb maturity carcasses have break joints on both shanks, slightly wide and moderately flat rib bones and a light red, fine textured lean. Yearling mutton carcasses may have either 2 break joints, 1 break joint and 1 spool joint or 2 spool joints, moderately wide rib bones that tend to be flat and a slightly dark red, slightly coarse textured lean. Mutton carcasses always have spool joints on both shanks, tend to have wide, flat rib bones and a dark red, coarse textured lean.

Lean Quality: Lean quality is best evaluated by direct observation of texture, firmness and marbling in a cut surface. In lamb grading, direct observation is not possible. Lean quality in lamb carcasses is evaluated indirectly by the quantity of fat streakings within and upon the inside flank muscles. In addition, Prime carcasses must have minimum lean firmness score of "moderately firm" and Choice carcasses must have at least "slightly firm" lean.

Conformation: The conformation of a carcass is evaluated by considering all carcass components but giving particular attention to the more desirable cuts. Superior conformation carcasses are very wide and thick in relation to their length and should produce a higher proportion of edible product. Poor conformation lamb carcasses are thinly muscled and have a less desirable lean to bone ratio.

Balancing Grade Factors: Lamb skeletal and lean maturity is combined with the amount of flank fat streakings to arrive at a quality grade. As maturity increases, there is an increasing requirement in the amount of fat flank streakings. For example, to be eligible for the Choice grade the minimum fat flank streaking requirement for lamb (young lamb) maturity carcasses is "Traces". However, for yearling mutton, the minimum fat flank streaking requirement for the Choice grade is "Small" and for mutton carcasses the minimum requirement is "Modest".

The lamb grading standards give minimum carcass conformation scores for each quality grade. However, superior quality can compensate on an equal basis for inferior conformation. A carcass that has average Prime lean quality and average Choice conformation would still qualify for the Prime grade. Also, in the Choice and Good grades, superior conformation can compensate for inferior quality by 1/3 of a grade. For example, a carcass with Good + lean quality can qualify for the Choice grade with average Choice conformation. Regardless of the extent that conformation exceeds minimum requirements, a carcass must have minimum Prime lean quality to qualify for USDA Prime. To be eligible for Choice and Prime grades, carcasses must have at least a thin covering of fat over the back (muscles no more than plainly visible).

Adapted from University of Nebraska Publication G83-675-A

Dakota Lean Lamb

Three traits will be the basis for Dakota Lean Lamb: fat cover, conformation score, and flank color. Fat cover is the most important predictor of cutability and is measured between the 12th and 13th ribs. Conformation score is an indicator of carcass muscling. Superior conformation scores (higher number codes) are very wide and thick which should indicate a high muscle mass. Narrow, angular conformation (lower number codes) will have a lower proportion of edible meat. Flank color is an indicator of youthfulness with soft reddish pink being the most desirable.

Score 14 Score 12 Score 10

Dakota Lean Lamb carcasses are very youthful in appearance; wide and thick in their outline; and carrying very little fat cover which in turn should produce a higher proportion of edible product for the consumer.

<u>To qualify as a Dakota Lean Lamb, the following must be met:</u>

Carcass weight: 55 - 75 lbs.
Fat thickness at 12-13th rib: 0.10-0.30 in
Conformation score of 13-15
Flank color: soft reddish pink

Proposal prepared by Roger G. Haugen, Extension Sheep Specialist and reviewed by Dr. Paul Berg, NDSU Meat Specialist

Economic Analysis of Controlling Leafy Spurge with Sheep

Dean A. Bangsund, Dan J. Nudell, Randall S. Sell, and F. Larry Leistritz*

INTRODUCTION

Leafy spurge (*Euphorbia esula* L.), first introduced in North America in the 19th century, was found in North Dakota in 1909, and was considered a threat to rangeland in the Great Plains as early as 1933 (Hanson and Rudd 1933). The weed currently infests large amounts of untilled land in the Plains and Mountain states. Once established on untilled land, the weed spreads quickly, displacing native vegetation. Leafy spurge has unique characteristics that give it a competitive advantage over most native plants and provide it with natural defenses against cattle grazing. Leafy spurge can create serious economic losses for land owners and ranchers.

Current control technologies are ineffective in eradicating established infestations. Although leafy spurge can be controlled through chemical, biological, and cultural methods, each control approach has limitations in its applicability and effectiveness in treating all leafy spurge infestations. However, many of the constraints prohibiting herbicides, tillage, and biological controls (i.e., prohibitive expense, unsuitable land, and physiological barriers) do not appear to eliminate sheep grazing as a possible control. Grazing with sheep and goats, while known to be effective in controlling leafy spurge since the 1930s, lacks widespread adoption (Sedivec et al. 1995; Sell et al. 1998). Many questions remain regarding the economic feasibility of using sheep to control leafy spurge. A goal of this study is to help determine how sheep grazing could fit into an integrated pest management approach to control leafy spurge by providing economic information for land owners to use in assessing their long-term control strategies.

OBJECTIVE

The purpose of this report is to evaluate the economic feasibility of using sheep to control leafy spurge in rangeland.

PROCEDURES

Since sheep will not eradicate leafy spurge, assessment of leafy spurge control requires identifying the benefits and costs of treatment over extended periods. This study focused on the economic feasibility of control, which compares long-term costs with long-term benefits. Financial and operational constraints, such as cash flow, available capital, and labor requirements, were not included.

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*Bangsund and Sell are research scientists and Leistritz is a professor, Department of Agricultural Economics, North Dakota State University, Fargo; Nudell is a research specialist at the Hettinger Research Extension Center, North Dakota State University, Hettinger.

Model Development

A model was developed to evaluate the benefits and costs of using sheep to control leafy spurge. Given an initial leafy spurge infestation, the model predicts leafy spurge spread and the corresponding annual losses in cattle grazing if the infestation was left uncontrolled over various periods. The effects of sheep grazing on infestation canopy cover (i.e., density), spread rates, grass rejuvenation, and grazing recovery rates for cattle were incorporated. The dynamics of control (i.e., changes in canopy cover, rate of spread, and grass recovery) were based on secondary information and consultation with weed and range scientists. The economic feasibility of using sheep to control leafy spurge was evaluated using various scenarios which reflect likely situations facing cattle ranchers implementing a sheep enterprise for leafy spurge control.

Costs of using sheep to control leafy spurge include fencing expenses and net returns from a sheep enterprise (which could be positive or negative) or expenses from leasing sheep. Benefits of control include (1) recouping lost grazing outputs (for cattle) from within the infestation (grazing recovery) and (2) maintaining existing grazing capacity by preventing current infestations from expanding (grazing retention).

Two economic perspectives were considered: (1) treatment costs were compared to treatment benefits (i.e., classic benefit-cost analysis) and (2) potential losses without control were compared to losses incurred using sheep to control leafy spurge (i.e., least-loss or cost-minimization analysis). In the first analysis, treatment situations where returns are greater than costs are economical. In the second analysis, treatments where economic losses are less when using sheep to control leafy spurge than would be incurred without controlling leafy spurge would be economically advisable, providing alternative control strategies were not available. When a no-control strategy (i.e., leaving the infestation alone) results in less economic loss than would be incurred when implementing a control strategy using sheep, a "do nothing" strategy or one employing other control methods (e.g., herbicides, biocontrol, and/or tillage/reseeding) might be optimal.

Sheep Enterprises

A basic premise in this study was that sheep would be added to leafy spurge infested rangeland either through (1) adoption of a sheep enterprise by an existing ranch or (2) leasing sheep during the grazing season.

Two lease rates were used in this study--$1 per head per month and $2 per head per month. The lessee would only be responsible for providing adequate fencing and water during summer grazing.

Sheep enterprises that would be used primarily for leafy spurge control were based on typical western North Dakota farm operations. Sheep were assumed to lamb prior to spring calving, thereby not interfering with beef operations. Only ewes and rams were used for leafy spurge control. Lambs were assumed to be weaned before summer grazing and retained in feedlots until fall.

Costs and revenues for several sheep enterprises were developed to accommodate different flock size, performance, and financial characteristics. Variable costs, such as shearing, utilities, fuel, etc., were assumed equal (i.e., per ewe) among all enterprises. Economic charges (depreciation) were not included for machinery and equipment that overlap with cattle production. Selling prices for lambs, cull ewes, and wool represented a 5-year average of North Dakota prices (ND Agricultural Statistics *various years*).

Two flock sizes were developed. Small flocks had 60 ewes and 2 rams and large flocks had 200 ewes and 6 rams. Flocks were further categorized by those with debt and those without debt. The enterprises with debt were assumed to have 50 percent of the equipment and facility requirements financed for 5 years and 50 percent of the breeding stock purchases financed for 3 years. Loan interest rate was 10 percent. After the first three to four years of a grazing control program, the number of sheep needed for leafy spurge control generally decreases (Sedivec et al. 1995). Budgets for each production scenario were estimated annually over a 10-year period to accommodate changes in flock size and debt expiration. Production coefficients, selling prices, and variable expenses were fixed over the 10-year period.

Flock performance (e.g., lambing rate, weaning rate, rate of gain, death loss) will likely vary depending upon management ability, animal husbandry, and willingness and ability of ranchers to devote resources to flock management. One management situation was based on flock performance achieved by established sheep producers in North Dakota (good management scenarios). The other situation was based on flock performance levels below that of unassisted lambing flocks on the Hettinger Research Station (poor management scenarios) (Hettinger Research Extension Center 1999). The two management scenarios evaluated (good and poor) represent likely extremes in flock performance. Good management scenarios were designed to represent "best case" situations; whereas, poor management scenarios were designed to represent "worst case" situations. The most realistic outcome for the majority of ranchers adopting a sheep enterprise will likely be somewhere in between those two extremes.

Leafy Spurge Control

Leafy spurge control with sheep will vary depending upon the grazing system employed. Rotational (two 1-month periods) and seasonal (4 months) grazing strategies were considered. Both grazing systems were expected over time (several grazing seasons) to reduce existing infestation canopy cover and also prevent plant spread.

A mixed-species grazing approach was assumed. The number of sheep required for control was based on one ewe per acre of leafy spurge. The stocking rate for cattle was assumed to remain unchanged the first year of sheep grazing and assumed to increase over time as the carrying capacity (for cattle) increased with improved levels of leafy spurge control. This study assumed (1) ranchers adjusted cattle stocking rates or grazing duration to accommodate the increase in grazing output, (2) initial cattle stocking rates were appropriate for the land prior to leafy spurge treatment, and (3) reductions in sheep stocking rates were implemented over time.

The expected level of leafy spurge control was based on information obtained from secondary sources and consultation with weed and range scientists. Control of leafy spurge was based on the number of years of grazing assuming the same flock is used to graze leafy spurge each year and that proper stocking rates are maintained (Figure 1). Control was defined as a percentage of the previous year's density or canopy cover {e.g., density(year 2)-[density(year 2) x control(year 2)] = density(year 3)}.

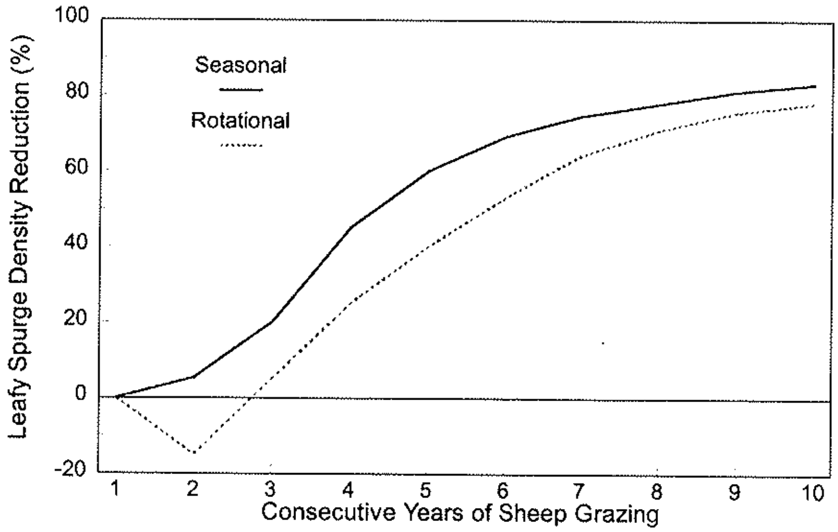

Figure 1. Leafy Spurge Control with Sheep Grazing, Seasonal and Rotational Strategies

The rate of leafy spurge spread was also based on the number of years of grazing. Since leafy spurge can expand at various rates, reduction in the rate of spread was estimated as a percentage of actual spread (Figure 2). In a seasonal grazing strategy, leafy spurge expansion is halted in the fourth year of sheep grazing. In a rotational grazing strategy, five years of sheep grazing would be required to halt leafy spurge expansion.

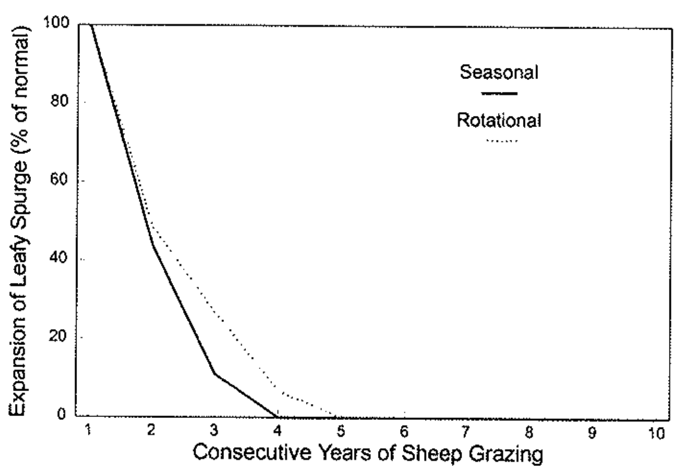

Figure 2. Rate of Leafy Spurge Expansion with Sheep Grazing, Seasonal and Rotational Strategies

Grazing Reduction Model

One of the key components in the model is the relationship between infestation density or canopy cover and lost grazing capacity (for cattle). In order to estimate the losses from leafy spurge infestations, the analysis of the economics of sheep grazing required estimating the amount of forage lost to cattle that results from various levels of leafy spurge infestation. The degree of lost grazing capacity within a leafy spurge infestation was estimated as linear function of canopy cover (Figure 3). The model assumes that a 30 percent canopy cover would roughly translate to about 80 to 130 stems/M^2.

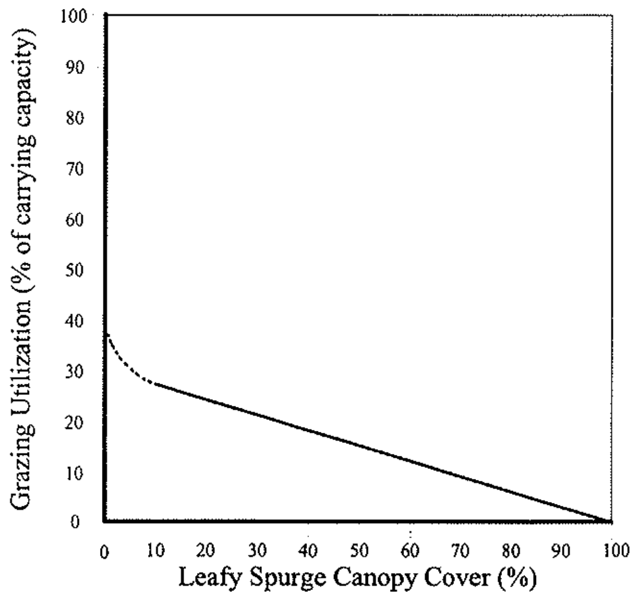

Figure 3. Reduction in Cattle Grazing within Leafy Spurge Infestations
Source: Kirby (1999).

Forage Recovery

The relationships between canopy cover reduction, grass utilization (cattle), and grass production over time were estimated from secondary sources (Lym et al. 1997; Sedivec et al. 1995) and from consultation with weed and range scientists.

The basic approach to estimating the amount of forage consumed by cattle was based on two factors: (1) the amount of grass available within leafy spurge infestations and (2) the amount of available grass that cattle would graze. The model assumes that as leafy spurge infestations increase in density, grass production within those infestations decreases (Figure 4). The relationship between leafy spurge density and grass production was based on the ability of leafy spurge to outcompete native vegetation and create near monocultures (Watson 1985; Messersmith et al. 1985).

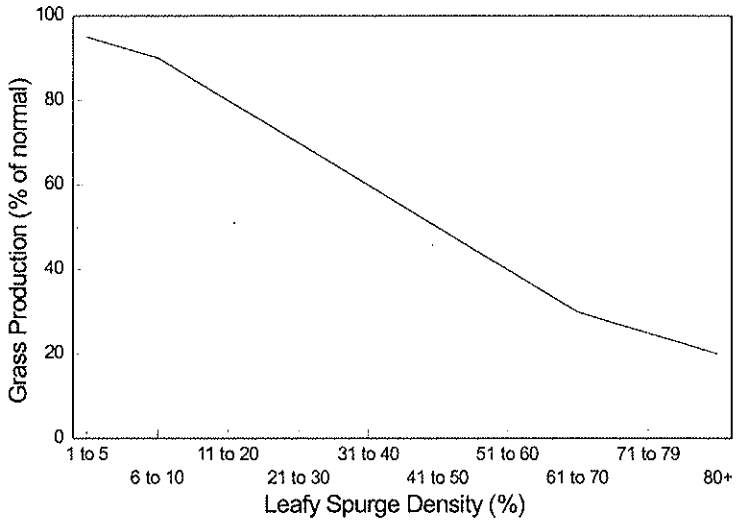

Figure 4. Grass Production and Leafy Spurge Infestation Density

Since sheep will not eradicate leafy spurge, the model assumes that sheep will not eliminate enough leafy spurge to bring infestation sites back to their pre-infestation carrying capacity. Since control was based on a function of time, the rate of grass consumption by cattle was also modeled as a function of the number of years of sheep grazing (Figure 5). Even though grass production within the infestation was modeled to increase over time as infestation density was reduced, grass production was assumed to remain below that of uninfested rangeland even after 10 years of sheep grazing.

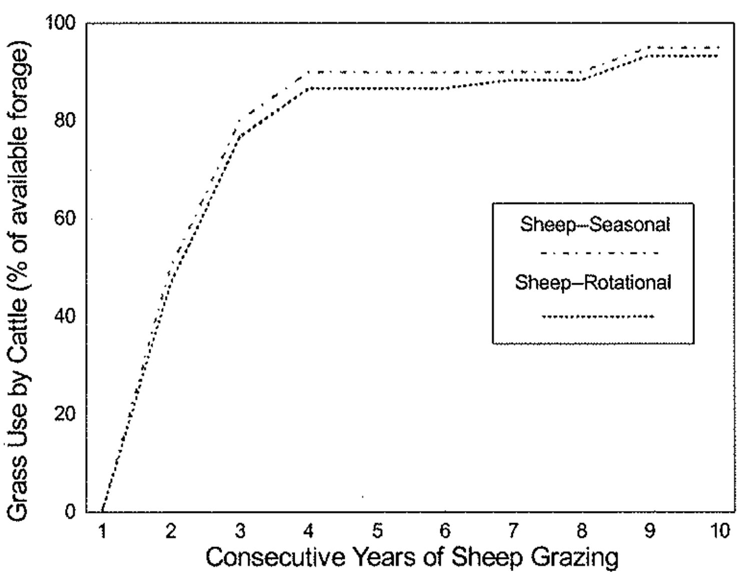

Figure 5. Grass Consumption by Cattle within Leafy Spurge Infestations Controlled with Sheep Grazing

RESULTS

Results provide a look at the long-term economic feasibility of using sheep to control leafy spurge under a variety of plausible situations facing landowners in the upper Great Plains. Actual control and treatment conditions will likely differ from those used in this study.

Sheep Enterprises

Several possible sheep enterprise scenarios were budgeted to accommodate differences in flock performance, debt structure, and flock size. Annual budgets were generated to accommodate changes in flock size and debt expiration over time. Net returns, excluding fence costs and taxes, for the various sheep enterprises ranged from ($5.82) to $45.14 per ewe in year 1 of the 10-year budgeting period (Table 1).

Fencing costs were estimated separately from the sheep enterprise budgets to accommodate various combinations of pasture size and leafy spurge infestations for all scenarios. Thus, fencing costs would reflect the appropriate expense for multiple combinations of pasture size, new or modified fence, and infestation size, regardless of the other factors influencing enterprise returns. Fencing materials were based on August 1998 retail prices for wire and posts in Hettinger, North Dakota. Labor expense was not included. Water development costs also were not included as existing pastures were assumed to have adequate water sources which would require minimal effort to modify for their use by sheep.

Table 1. Returns to Unpaid Labor, Management, and Equity for Various Sheep Enterprise Scenarios, Western North Dakota[a]

	Good Management[b]				Poor Management[c]			
	Debt[d]		No Debt		Debt		No Debt	
Year	Small[e]	Large[e]	Small	Large	Small	Large	Small	Large
	dollars per ewe							
1 & 2	30.09	41.25	34.56	45.21	(5.58)	(3.25)	(1.23)	0.62
3	22.02	32.88	26.48	36.85	(16.45)	(14.40)	(12.09)	(10.54)
4 & 5	30.26	32.46	31.59	32.99	(3.79)	(0.78)	(2.46)	(0.25)
6	31.59	32.99	31.59	32.99	(2.46)	(0.25)	(2.46)	(0.25)
7	26.18	27.99	26.18	27.99	(10.57)	(8.04)	(10.57)	(8.04)
8 - 10	24.54	31.67	24.54	31.67	(6.90)	(1.64)	(6.90)	(1.64)

[a] Net returns do not include fencing costs or taxes.

[b] Good management based on flock performance (i.e., lambing rate, weaning rate, death loss, etc.) obtained by proven sheep producers in North Dakota (Hettinger Research Extension Center 1999).

[c] Poor management represents a low level of flock efficiency and productivity, specifically, performance below that of unassisted lambing flocks at the Hettinger Research Extension Center (Hettinger Research Extension Center 1999).

[d] Debt included financing one-half of the breeding flock for three years and one-half of equipment and building expenses for five years at 10 percent interest.

[e] Small flocks based on 60 ewes and large flocks based on 200 ewes. Flock reductions occurred in years 4 and 8.

Fencing expenses included modifying an existing fence or constructing new fence. Modified fencing was based on adding 2 barb wires to an existing 3- or 4-wire fence. New fence was based on 6 barb wires, including requirements for line and corner posts. Five percent of total fencing expenses was charged to the enterprise budgets each year.

Within the range of fencing costs examined, fencing expense (i.e., 5 percent of total fence expense) ranged from $0.10 to $8.49 per ewe per year with seasonal grazing. In the scenarios including debt, 50 percent of total fencing costs was assumed to be financed for five years at 10 percent interest. The interest expense in financing fencing debt was included as an additional fencing expense. Fencing costs per ewe for new fence were generally five to six times higher than costs of modifying an existing fence.

Feasibility of Long-term Control--Sheep Enterprises

This section discusses the economic feasibility of using sheep to control leafy spurge through adding a sheep enterprise to an existing ranch. Several variables were held constant across all analyses. Pasture size was limited to 350 acres. Grazing recovery and retention were valued at $15 per AUM. All analyses were evaluated using 5, 15, and 30 percent canopy cover for the leafy spurge infestation, which correspond with low (17 percent loss), moderate (50 percent loss), and high (100 percent) grazing losses (for cattle) within the leafy spurge infestation, respectively. Results are presented for a 10-year period.

Seasonal Grazing

Seasonal grazing strategies were based on grazing sheep for four months, with grazing initiated in May. Four of the eight scenarios evaluated had positive net returns for the sheep enterprise (see Table 1). Under those circumstances, even with modest levels of leafy spurge control, using sheep as a leafy spurge control will be economical. However, with negative enterprise returns, the cost of control (i.e., money lost maintaining the sheep enterprise) must be balanced with the benefits of control (i.e., value of leafy spurge control and grazing output for cattle).

Benefit-cost Analysis

The good management scenarios revealed substantial positive returns from leafy spurge control. Total net returns (discounted treatment returns less discounted treatment costs) from leafy spurge control, with rangeland carrying capacities of 0.20 AUMs per acre, ranged from $123 to $219 per acre of leafy spurge, depending upon fencing obligations, debt, and flock size. When rangeland carrying capacity increased to 0.80 AUMs per acre, total net returns from leafy spurge control ranged from $137 to $262 per acre of leafy spurge (Table 2).

The poor management scenarios revealed that net returns from leafy spurge control were sensitive to rangeland productivity and leafy spurge canopy cover. Total net returns from leafy spurge control, with rangeland carrying capacities of 0.20 AUMs per acre, ranged from $(72) to $(1) per acre of leafy spurge, depending upon fencing obligations, debt, and flock size. When rangeland carrying capacity increased to 0.80 AUMs per acre, total net returns from leafy spurge control ranged from $(58) to $42 per acre of leafy spurge (Table 2).

Table 2. Total Net Returns Per Acre from the Control of Leafy Spurge Using Sheep with Seasonal Grazing Scenarios over 10 Years[a]

	50-acre Infestation						250-acre Infestation					
	Infestation Canopy Cover						Infestation Canopy Cover					
Carrying	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Capacity	Modify Fence			New Fence			Modify Fence			New Fence		
AUMs/acre	good management with no debt											
0.20	167.8	171.6	177.4	145.9	149.7	155.5	209.5	213.3	219.0	202.9	206.7	212.5
0.40	172.6	180.2	191.8	150.7	158.3	169.9	214.2	221.7	233.2	207.6	215.2	226.7
0.60	177.4	188.8	206.2	155.5	166.9	184.3	218.9	230.2	247.5	212.3	223.6	240.9
0.80	182.1	197.4	220.6	160.3	175.5	198.7	223.6	238.6	261.7	217.0	232.1	255.1
	good management with debt											
0.20	152.3	156.1	161.9	122.7	126.6	132.4	197.4	201.2	206.9	188.6	192.3	198.1
0.40	157.0	164.7	176.3	127.5	135.2	146.8	202.1	209.6	221.2	193.3	200.8	212.3
0.60	161.8	173.3	190.7	132.3	143.8	161.2	206.8	218.1	235.4	198.0	209.2	226.5
0.80	166.6	181.9	205.1	137.1	152.4	175.5	211.5	226.6	249.6	202.7	217.7	240.7
	poor management with no debt											
0.20	-27.7	-23.9	-18.1	-49.5	-45.7	-39.9	-10.5	-6.7	-0.9	-17.0	-13.3	-7.5
0.40	-22.9	-15.3	-3.7	-44.8	-37.1	-25.5	-5.8	1.8	13.3	-12.3	-4.8	6.7
0.60	-18.1	-6.7	10.7	-40.0	-28.5	-11.1	-1.1	10.2	27.5	-7.6	3.7	20.9
0.80	-13.3	1.9	25.1	-35.2	-19.9	3.3	3.6	18.7	41.7	-2.9	12.1	35.2
	poor management with debt											
0.20	-42.9	-39.1	-33.3	-72.4	-68.6	-62.8	-22.2	-18.5	-12.7	-31.1	-27.3	-21.6
0.40	-38.1	-30.5	-18.9	-67.6	-60.0	-48.4	-17.5	-10.0	1.5	-26.4	-18.9	-7.4
0.60	-33.3	-21.9	-4.5	-62.8	-51.4	-34.0	-12.8	-1.6	15.7	-21.7	-10.4	6.9
0.80	-28.5	-13.3	9.9	-58.1	-42.8	-19.6	-8.1	6.9	29.9	-17.0	-2.0	21.1

[a]Fencing costs based on a 350-acre pasture. Returns discounted annually at 4 percent. Low, medium, and high rates of leafy spurge canopy cover translate to about 17, 50, and 100 percent reductions in cattle grazing within the leafy spurge infestations, respectively. AUMs valued at $15. Debt included one-half of breeding stock financed for three years and one-half of equipment financed for five years. Interest rate at 10 percent.

Generally, net returns from leafy spurge control were about $12 to $23 per acre higher for scenarios having no debt versus those with debt (e.g., good management without debt compared to good management with debt) (Table 2). Over a 10-year period, net returns from leafy spurge control were $26 per acre less for scenarios with new fence versus modified fence across all management scenarios with small infestations and net returns from leafy spurge control were $8 per acre less with large infestations. Net returns per acre from leafy spurge control were higher with large infestations (250-acre) versus small infestations (50-acre) across all scenarios. In a 10-year period, net returns from large infestations compared to small infestations improved by $17 to $45 per acre for all scenarios with modified fence. For all scenarios with new fence over the same period, net returns from leafy spurge control improved by $33 to $66 per acre when comparing large to small infestations.

Least-loss Analysis

Least-loss analysis compares the economic losses that would occur if a leafy spurge infestation was left uncontrolled to the losses incurred with control. In situations where economic losses with treatment are more than the economic losses incurred with no control, the treatment program or method would not be recommended.

The good management scenarios had positive enterprise returns (even after fencing expenses), which resulted in positive returns from control. Thus, least-loss analyses were not conducted for those scenarios. Least-loss scenarios were conducted for the poor management scenarios.

Over a 10-year period, most sheep grazing scenarios with high rangeland productivity and high leafy spurge cover resulted in less economic loss than with no control (Table 3). Many of the scenarios with new fence and low leafy spurge cover would not be recommended within a 10-year period. However, with new fence and high leafy spurge cover, both large and small infestations could be recommended for all but the least productive rangeland. In a 10-year period, none of the small flock scenarios would be recommended at rangeland carrying capacities of 0.20 AUMs per acre (Table 3).

Rotational Grazing

Rotational (two 1-month periods) grazing strategies were evaluated. In a rotational system, sheep would graze the infestation for one month periods at a higher stocking rate than used in seasonal grazing. Sheep grazing would be initiated in May. Sheep would graze the same pasture a total of two nonconsecutive months during the grazing season. Other rotational grazing programs were not evaluated.

Benefit-cost Analysis

The good management scenarios revealed substantial positive returns from leafy spurge control with rotational grazing systems. Total net returns (discounted treatment returns less discounted treatment costs) from leafy spurge control, with rangeland carrying capacities of 0.20 AUMs per acre, ranged from $114 to $218 per acre of leafy spurge, depending upon fencing obligations, debt, and flock size. When rangeland carrying capacity increased to 0.80 AUMs per acre, total net returns from leafy spurge control ranged from $127 to $259 per acre of leafy spurge (Table 4).

Table 3. Least-loss Analysis of the Control of Leafy Spurge Using Sheep, Poor Flock Management, Seasonal and Rotational Grazing Scenarios[a]

Carrying Capacity	50-acre Infestation: Infestation Canopy Cover						250-acre Infestation: Infestation Canopy Cover					
	Modify Fence			New Fence			Modify Fence			New Fence		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
AUMs/acre	poor management, no debt, seasonal grazing											
0.20	no	no	no	no	no	no	no	yes	yes	no	no	yes
0.40	no	yes	yes	no	no	yes	yes	yes	yes	no	yes	yes
0.60	no	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes
0.80	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes
	poor management, with debt, seasonal grazing											
0.20	no	no	no	no	no	no	no	no	yes	no	no	no
0.40	no	no	yes	no	no	no	no	yes	yes	no	no	yes
0.60	no	yes	yes	no	no	yes	yes	yes	yes	no	yes	yes
0.80	no	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes
	poor management, no debt, rotational grazing											
0.20	no	no	no	no	no	no	no	yes	yes	no	no	yes
0.40	no	yes	yes	no	no	no	yes	yes	yes	no	yes	yes
0.60	no	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes
0.80	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes
	poor management, with debt, rotational grazing											
0.20	no	no	no	no	no	no	no	no	yes	no	no	no
0.40	no	no	yes	no	no	no	no	yes	yes	no	no	yes
0.60	no	yes	yes	no	no	no	no	yes	yes	no	yes	yes
0.80	no	yes	yes	no	no	yes	yes	yes	yes	no	yes	yes

[a]Fencing costs based on a 350-acre pasture. Returns discounted annually at 4 percent. Low, medium, and high rates of leafy spurge canopy cover translate to about 17, 50, and 100 percent reductions in cattle grazing within the leafy spurge infestations, respectively. AUMs valued at $15.

Note: In situations where net returns from using sheep to control leafy spurge are negative, least-loss analysis indicates if using sheep grazing to control leafy spurge would result in less economic loss than if the leafy spurge infestation was left uncontrolled. A "yes" implies that the scenario will result in less economic loss than no treatment. A "no" implies that the scenario will result in more economic loss than no treatment.

Table 4. Total Net Returns Per Acre from the Control of Leafy Spurge Using Sheep with Rotational Grazing Scenarios over 10 Years[a]

Carrying Capacity	50-acre Infestation, Infestation Canopy Cover						250-acre Infestation, Infestation Canopy Cover					
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
	Modify Fence			New Fence			Modify Fence			New Fence		
AUMs/acre	good management with no debt											
0.20	166.1	169.9	175.6	139.5	143.4	149.0	208.7	212.5	218.1	200.7	204.5	210.1
0.40	170.5	178.2	189.5	143.9	151.6	162.9	213.0	220.6	231.8	205.0	212.6	223.8
0.60	174.9	186.4	203.3	148.3	159.8	176.8	217.3	228.6	245.5	209.3	220.7	237.5
0.80	179.3	194.6	217.2	152.7	168.0	190.6	221.6	236.7	259.2	213.6	228.7	251.2
	good management with debt											
0.20	150.1	154.0	159.6	114.2	118.1	123.7	196.5	200.3	205.9	185.7	189.5	195.1
0.40	154.5	162.2	173.5	118.6	126.3	137.6	200.8	208.4	219.6	190.0	197.6	208.8
0.60	158.9	170.4	187.4	123.0	134.5	151.5	205.1	216.4	233.3	194.3	205.7	222.5
0.80	163.3	178.6	201.2	127.4	142.7	165.3	209.4	224.5	247.0	198.6	213.7	236.2
	poor management with no debt											
0.20	-29.4	-25.5	-19.9	-55.9	-52.1	-46.5	-11.2	-7.5	-1.8	-19.2	-15.4	-9.8
0.40	-25.0	-17.3	-6.0	-51.6	-43.9	-32.6	-6.9	0.6	11.8	-14.9	-7.4	3.9
0.60	-20.6	-9.1	7.9	-47.2	-35.7	-18.7	-2.6	8.7	25.5	-10.6	0.7	17.6
0.80	-16.2	-0.9	21.7	-42.8	-27.5	-4.8	1.7	16.8	39.2	-6.3	8.8	31.3
	poor management with debt											
0.20	-45.0	-41.2	-35.5	-80.9	-77.1	-71.4	-23.2	-19.4	-13.8	-33.9	-30.2	-24.5
0.40	-40.6	-33.0	-21.6	-76.5	-68.9	-57.5	-18.9	-11.3	-0.1	-29.6	-22.1	-10.8
0.60	-36.2	-24.8	-7.8	-72.1	-60.7	-43.7	-14.6	-3.2	13.6	-25.3	-14.0	2.8
0.80	-31.9	-16.5	6.1	-67.8	-52.4	-29.8	-10.3	4.8	27.3	-21.0	-5.9	16.5

[a]Fencing costs based on a 350-acre pasture. Returns discounted annually at 4 percent. Low, medium, and high rates of leafy spurge canopy cover translate to about 17, 50, and 100 percent reductions in cattle grazing within the leafy spurge infestations, respectively. AUMs valued at $15. Debt included one-half of breeding stock financed for three years and one-half of equipment financed for five years. Interest rate at 10 percent.

The poor management scenarios revealed that net returns from leafy spurge control were sensitive to rangeland productivity and leafy spurge canopy cover. Total net returns from leafy spurge control, with rangeland carrying capacities of 0.20 AUMs per acre, ranged from $(81) to $(2) per acre of leafy spurge, depending upon fencing obligations, debt, and flock size. When rangeland carrying capacity increased to 0.80 AUMs per acre, total net returns from leafy spurge control ranged from $(68) to $39 per acre of leafy spurge (Table 4).

The pattern of net returns from control using rotational grazing strategies were similar to those with seasonal grazing strategies for all periods. Total returns over a 10-year period for all of the poor management, rotational grazing scenarios with low leafy spurge canopy cover remained negative with moderate to high rangeland carrying capacities (i.e., less than 0.80 AUMs/acre). However, in one scenario with high leafy spurge canopy cover, net returns over a 10-year period were positive down to 0.30 AUMs per acre carrying capacity (Table 4).

Generally, returns from leafy spurge control in rotational grazing scenarios were about $12 to $25 per acre higher for scenarios having no debt versus those with debt (Table 4). Over a 10-year period, returns from leafy spurge control with rotational grazing systems were $31 per acre less for scenarios with new fence versus modified fence across all management scenarios with small infestations, and $9 per acre less with large infestations. In a 10-year period, returns from large infestations compared to small infestations improved by $18 to $46 per acre for all scenarios with modified fence. For all scenarios with new fence over the same period, returns from leafy spurge control improved by $37 to $71 per acre when comparing large to small infestations.

Least-loss Analysis

The good management scenarios in the rotational grazing systems had positive enterprise returns (even after fencing expenses), which result in positive returns from control. Thus, least-loss analyses were not conducted for those scenarios. However, least-loss scenarios were conducted for the poor management scenarios.

Over the 10-year period, most scenarios with high rangeland productivity and high leafy spurge cover with large infestations resulted in less economic loss than with no control (Table 3). Many of the scenarios with new fence and low leafy spurge cover would not be recommended over a 10-year period. However, with new fence and high leafy spurge cover, both large and small flock scenarios could be recommended for all but the least productive rangeland. No small flock scenarios would be recommended at rangeland carrying capacities of 0.20 AUMs per acre (Table 3).

Feasibility of Long-term Control--Sheep Leasing

An alternative to adopting a sheep enterprise would be to lease sheep for leafy spurge control. Leasing sheep for leafy spurge control would have some advantages over adding a sheep enterprise to an existing ranch. Many financial and operational constraints (e.g., capital, labor, facilities) inherent with adding another enterprise to an existing ranch operation would be eliminated with sheep leasing. However, leasing sheep would likely eliminate the potential net revenue generated from an additional enterprise. Expenses for leasing sheep would be similar in context to annual treatment expenses associated with herbicides (i.e., a rancher would be expected to pay some charge per acre per year for leafy spurge control).

Lease arrangements between a sheep owner and an individual desiring leafy spurge control could be numerous. The arrangement used for this study assumed that the animals would be leased on a monthly basis for only the time required for leafy spurge control. The lessee would not be responsible for death loss, health, or other flock maintenance duties during summer grazing. The lessee would be responsible for providing adequate fencing and water, along with sufficient forage for the period leased. Transportation was assumed the responsibility of the lessor. The only expenses for the lessee would be the monthly lease rate and fencing costs.

A critical assumption in the evaluation of leasing sheep for purposes of leafy spurge control was that the same flock would be leased over several years. The relationship between sheep grazing and leafy spurge control, in this study, was based on sheep becoming acclimated to eating leafy spurge. If, in a leasing arrangement, a rancher used sheep each year that were not acclimated to eating leafy spurge, control of leafy spurge would likely be less than the amount estimated in this analysis.

The economics of leasing sheep for leafy spurge control were evaluated using $1 per head per month and $2 per head per month lease rates. Each lease rate was evaluated according to the same format used in the sheep enterprise analyses. Seasonal grazing strategies were based on grazing sheep for four months, with grazing initiated in May. Rotational grazing strategies were not evaluated with sheep leasing.

Benefit-cost Analysis

Benefit-cost analysis of the two lease rates revealed that returns from leafy spurge control were sensitive to infestation size, infestation canopy cover, fencing costs, and lease rate. In a 10-year period, net returns for the $1 lease rate varied from ($50) to $(9) per acre of leafy spurge at 0.20 AUMs per acre carrying capacity, depending upon fencing obligations and infestation size. When rangeland carrying capacity increased to 0.80 AUMs per acre, total net returns from leafy spurge control with the $1 lease rate ranged from $(36) to $33 per acre of leafy spurge (Table 5).

Total net returns for the $2 lease rate varied from $(72) to $(31) per acre of leafy spurge at 0.20 AUMs per acre carrying capacity, depending upon fencing obligations and infestation size. When rangeland carrying capacity increased to 0.80 AUMs per acre, total net returns from leafy spurge control with the $2 lease rate ranged from $(58) to $11 per acre of leafy spurge (Table 5).

Over a 10-year period, returns from leafy spurge control with $1 and $2 lease rates, averaged over various carrying capacities, increased about $26 per acre when leafy spurge canopy cover increased from 5 percent to 30 percent (Table 5). Net returns from leafy spurge control were $26 per acre less for scenarios with new fence versus modified fence across all scenarios with small infestations, and $5 per acre less with large infestations. Net returns per acre from leafy spurge control were higher with large infestations (250-acre) versus small infestations (50-acre) across all scenarios. In a 10-year period, net returns from large infestations compared to small infestations improved by $5 per acre for $1 and $2 lease rates.

Table 5. Benefit-cost and Least-loss Analyses of the Control of Leafy Spurge Using Sheep Grazing, Sheep Leasing, Seasonal Grazing[a]

Carrying Capacity	50-acre Infestation, Infestation Canopy Cover						250-acre Infestation, Infestation Canopy Cover					
	Modify Fence			New Fence			Modify Fence			New Fence		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
AUMs/acre	$1 per head per month lease rate											
0.20	-23.6	-19.8	-14.0	-49.8	-46.0	-40.2	-18.7	-15.0	-9.2	-24.0	-20.2	-14.5
0.40	-18.8	-11.2	0.4	-45.0	-37.4	-25.8	-14.0	-6.5	5.0	-19.3	-11.8	-0.3
0.60	-14.0	-2.6	14.8	-40.3	-28.8	-11.4	-9.3	1.9	19.2	-14.6	-3.3	14.0
0.80	-9.2	6.0	29.2	-35.5	-20.2	3.0	-4.6	10.4	33.4	-9.9	5.1	28.2
	$2 per head per month lease rate											
0.20	-45.8	-42.0	-36.2	-72.0	-68.2	-62.4	-41.0	-37.2	-31.4	-46.2	-42.5	-36.7
0.40	-41.0	-33.4	-21.8	-67.3	-59.6	-48.0	-36.3	-28.7	-17.2	-41.5	-34.0	-22.5
0.60	-36.2	-24.8	-7.4	-62.5	-51.0	-33.6	-31.6	-20.3	-3.0	-36.8	-25.5	-8.3
0.80	-31.5	-16.2	7.0	-57.7	-42.4	-19.2	-26.9	-11.8	11.2	-32.1	-17.1	6.0
	$1 per head per month lease rate											
0.20	no	no	yes	no	no	no	no	no	yes	no	no	no
0.40	no	yes	yes	no	no	yes	no	yes	yes	yes	yes	yes
0.60	yes	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes
0.80	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes
	$2 per head per month lease rate											
0.20	no	no	no	no	no	no	no	no	no	no	no	no
0.40	no	no	yes	no	no	no	no	no	yes	no	no	yes
0.60	no	yes	yes	no	no	yes	no	yes	yes	no	yes	yes
0.80	no	yes	yes	no	no	yes	no	yes	yes	no	yes	yes

[a]Fencing costs based on a 350-acre pasture. Returns discounted annually at 4 percent. Low, medium, and high rates of leafy spurge canopy cover translate to about 17, 50, and 100 percent reductions in cattle grazing within the leafy spurge infestations, respectively. AUMs valued at $15.

Note: In situations where net returns from using sheep to control leafy spurge are negative, least-loss analysis indicates if using sheep grazing to control leafy spurge would result in less economic loss than if the leafy spurge infestation was left uncontrolled. A "yes" implies that the scenario will result in less economic loss than no treatment. A "no" implies that the scenario will result in more economic loss than no treatment.

Least-loss Analysis

Over a 10-year period with the $1 lease rate, nearly all scenarios with high rangeland productivity (0.60 AUMs per acre or higher) and high leafy spurge cover (30 percent canopy cover) resulted in less economic loss than with no control. Some of the scenarios with new fence and low leafy spurge cover would not be recommended over a 10-year period (Table 5). However, with new fence and high leafy spurge cover, both large and small infestations could be recommended for all but the least productive rangeland. In a 10-year period, the small infestation scenario with low leafy spurge cover and new fence would not be recommended, regardless of rangeland carrying capacity.

Over a 10-year period with the $2 lease rate, no scenarios with low leafy spurge cover would be recommended, regardless of rangeland productivity (Table 5). Some of the scenarios with modified fence and high leafy spurge cover would be recommended down to rangeland carrying capacities of 0.40 AUMs per acre. Most of the new fence, small infestation scenarios would not be recommended with the $2 lease rate over a 10-year period. Similarly, in the new fence, large infestation scenarios, only those with productive rangeland would be recommended (Table 5).

DISCUSSION

The following section identifies data and method shortcomings present in this study. Also, a general discussion of the factors influencing the economics of using sheep to control leafy spurge has been included.

Data and Method Shortcomings

A number of data and method shortcomings were present in this analysis. First, some key components of the model were based on "best estimates" of range and weed scientists. The first three to four years of leafy spurge control using sheep was based on range research; however, control in the remaining years was largely extrapolated from existing research data. The exact nature of leafy spurge control using sheep in years 5 through 10 has not been fully quantified. Also, the exact relationship between leafy spurge control and grass recovery is unknown.

A number of additional analyses could be used to show the sensitivity of net returns from leafy spurge control with different sets of model parameters (e.g., adjust model for less or more control, increase or decrease the amount of grass availability, use various rates of grass recovery). However, for sake of brevity, and since most of the existing relationships used in the model have not be been fully researched, additional scenarios showing the effects of different model parameters were not included.

All analyses were evaluated based on leafy spurge canopy cover levels of 5, 15, and 30 percent. These percentages were used to evaluate low, moderate, and high levels of grazing loss to cattle within leafy spurge infestations. Higher canopy cover percentages would not affect the amount of lost grazing to cattle, but would have implications for grass recovery and potential returns to control.

Sheep prices, enterprise proficiency, production costs, debt levels, and grazing values were fixed over the analysis period. Their values will likely fluctuate over time or vary for individual ranchers. The effects of changes in those values were not addressed in this study.

The effects of changing the values of some initial situation inputs were not included in the analysis. For example, all analyses were conducted using one spread rate for leafy spurge infestations. Also, the annual rate of increase in leafy spurge canopy cover was fixed across all analyses. Other fixed inputs included the overall size of the pasture (all analyses used a 350-acre pasture) and fixed sizes of leafy spurge infestations (only a 50-acre and 250-acre infestation). The sensitivity of net returns to changes in those values was not addressed, and the study results could be improved by including these additional analyses.

Multiple species grazing has been shown to improve range health and increase grazing output on rangeland, assuming proper stocking rates. Any additional benefits obtained from multiple species grazing were not included in the analysis. Sheep may also help control other weeds on rangeland, in addition to controlling leafy spurge. Potential benefits from additional weed control and improvements in range productivity stemming from multiple species grazing were not included in this study.

Labor costs were not included in the sheep enterprise budgets or in the fencing expenses. Thus, even though returns may be positive for many control situations, returns from control may not be sufficient to adequately compensate a rancher for labor inputs. What a rancher would consider adequate compensation for time and labor inputs is a question best resolved by individual ranchers.

This study examined the economics of using sheep grazing to control leafy spurge; however, the issue of the economics of control may be irrelevant if a ranch operation has other constraints to adopting a sheep enterprise. Other issues, which should be examined, include financial and operational constraints to using sheep as a control tool for leafy spurge. These constraints may include the financial feasibility of adding a sheep enterprise to an existing ranch. Financial feasibility would address the availability of capital, cash flow, and other financial characteristics of a ranch operation that may prohibit adoption of an additional enterprise. Operational constraints, such as labor availability and seasonal labor demands, may also pose restrictions on adopting an additional enterprise.

Factors Influencing Returns from Control

A multitude of factors can influence the economics of using sheep to control leafy spurge. One of the biggest factors influencing returns from leafy spurge control would be enterprise returns. When enterprise returns were positive, net returns from leafy spurge control were positive in all of the treatment situations examined. In some cases, returns from leafy spurge control were substantial. However, when sheep are leased or enterprise returns were negative, a number of other factors influence the economics of control.

Large infestations were more economical to treat than small infestations, based on the fundamental assumptions used in this study. Fencing costs were modeled to be less with larger infestations, since overall pasture size was fixed across infestation sizes. In reality, per acre fencing costs for a 200-acre infestation could be the same as a 50-acre infestation. Also, because some efficiencies in sheep production occur when moving from small flocks (e.g., 50 ewes) to large flocks (e.g., 200 ewes), enterprise returns (i.e., $ per ewe) improved with flock size. Thus, lower per ewe fencing costs and more favorable enterprise returns were major reasons for returns from control being more favorable with larger infestations.

With good flock management, returns from control were positive with both rotational and seasonal grazing strategies. However, rotational grazing scenarios were less economical than seasonal controls, due to reduced leafy spurge control and higher fencing costs associated with rotational grazing systems. However, differences in leafy spurge control between the two grazing systems for any particular situation may not match those used in this report.

Returns from control improved as leafy spurge canopy cover increased. As grazing losses for cattle increased, returns from leafy spurge control also increased. This relationship directly influenced the amount of grazing recovery that could be expected from leafy spurge control. Returns from leafy spurge control improved proportionally to changes in grazing recovery. Also, since sheep grazing was only evaluated using relatively large infestations, the value of grazing retention (i.e., grazing output retained by preventing infestation spread) was a small component of overall returns. The effects of much higher leafy spurge densities and levels of canopy cover would affect net returns from leafy spurge control if grass recovery and forage available within the infestations differed from the levels/relationships assumed in this study.

Returns from control were directly proportional to the productivity of rangeland. Returns also improved proportionally with increases in AUM values. As the two components increased, returns increased proportionally with changes in rangeland productivity and grazing output values. Thus, holding all other factors constant, returns were greater on more productive rangeland. Similarly, holding all factors constant, returns improved as AUM values increased.

The level of debt used in this study did affect returns from leafy spurge control. The level of debt used in this study had sufficient influence on returns from control (about $12 to $23 per acre) to affect decisions regarding the economics of using sheep to control leafy spurge. The effects of debt were most influential in the poor management scenarios. Debt expenses reduced enterprise returns and increased fencing expenses. If enterprise returns are positive after debt expenses, returns from control will still be positive. However, when enterprise returns were negative, debt expenses were sufficient in some situations to make sheep grazing of leafy spurge uneconomical. The effects of multiple debt levels and debt expenses were not included in this study.

The added expense for new fence had a much greater effect on returns from small infestations (expense was divided among fewer acres). Returns from control improved by $26 per acre with modified fence compared to new fence with small infestations; however, returns from control only increased by $7.50 per acre with modified fence compared to new fence with large infestations. The difference in net returns between new fence and modified fence scenarios for rotational grazing were greater than the differences with the seasonal grazing strategies. The increased fencing expense assumed in the rotational grazing systems accounted for the difference.

Lease rates of $2 per head per month were not economical in most control situations. However, a lease rate of $1 per head per month was economical in many of the control situations.

To recap, the factors influencing returns from using sheep to control leafy spurge have been highlighted:

AUM values--returns from control changed proportionally with changes in AUM values.

Rangeland productivity--returns from control changed proportionally with changes in rangeland productivity.

Enterprise returns--the level of management, or financial performance, of the sheep enterprise had substantial effects on returns. Labor costs were not included in either the sheep budgets or fencing expenses.

Sheep leasing--leasing sheep for leafy spurge control may be an attractive alternative to adding a sheep enterprise to an existing operation. However, lease rates above $1 per head per month were not economical in many situations.

Infestation size--returns from control increase as infestation size increased across constant pasture sizes. Between the two infestation sizes evaluated, large infestations substantially increased net returns per acre over smaller infestations.

Fence expenses--modified fence was more economical than new fence, although the additional cost of new fence was not as prevalent in large infestations, assuming fixed pasture size. Expenses for new fence had more effect on returns from control in rotational grazing systems.

Debt costs--returns from control were less in the enterprise scenarios with debt; however, debt costs alone did not greatly influence overall returns from leafy spurge control.

Grazing system--seasonal grazing was more economical than rotational grazing, largely because rotational grazing had lower leafy spurge control rates and higher fencing costs.

Infestation canopy cover--as infestation canopy cover increased (ability of cattle to graze within the infestation decreased), returns from control increased. The range of canopy cover evaluated only ranged from 5 to 30 percent. Returns from control of much denser leafy spurge infestations would likely differ from the results presented in this study.

CONCLUSIONS

Very little information is available regarding the economics of using sheep to control leafy spurge. The primary goal of this research was to evaluate the economics of using sheep to control leafy spurge over a wide range of situations. Although a wide range of situations were evaluated, many of the key relationships between sheep grazing and forage recovery (cattle) have not be quantified. These relationships were estimated, for purposes of this study, based on assumptions and "best estimates" of weed and range scientists. Thus, until these relationships can be further refined, much of the economic analysis provided by this research remains sensitive to those key assumptions and relationships. However, the results from this preliminary research do provide important insights into the economics of using sheep to control leafy spurge.

The basic premise for this study was that sheep would be added to leafy spurge infested rangeland either through (1) adoption of a sheep enterprise by an existing ranch or (2) leasing sheep during the grazing season.

Several possible sheep enterprise scenarios were developed, which would represent a reasonable range of flock performance and financial conditions which could be expected from cattle ranchers. Sheep grazing as a leafy spurge control method was economical across many of enterprise scenarios developed. However, a number of other factors, such as additional labor requirements and financial constraints, need to be considered before implementing a grazing control strategy. Labor costs were not included in the sheep enterprise budgets or in the fencing expenses. Thus, even though returns may be positive for many control situations, returns from control may not be sufficient to adequately compensate a rancher for labor inputs. Providing these constraints do not prohibit adding a sheep enterprise to an existing ranch, the economics of using sheep grazing to control leafy spurge appear favorable. In many of the scenarios with negative sheep enterprise returns, the benefits of leafy spurge control outweighed the costs of control (enterprise returns and fencing expenses). Thus, controlling leafy spurge with sheep grazing can be economical even if the sheep enterprise had negative enterprise returns.

The economics of using sheep grazing to control leafy spurge appear promising. While using sheep to control leafy spurge could be economical in many situations (based on the limitations in this study), a careful evaluation using site- and rancher-specific inputs would be recommended before implementing sheep grazing as a leafy spurge control method. As with any decision regarding a long-term strategy to control leafy spurge, information in this study should be used in conjunction with other information and with consultation with weed scientists when formulating long-term control strategies.

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How to Obtain Additional Information

This report is a summary of a more comprehensive report which contains additional information. Additional copies of this summary and single copies of the main report, *Economic Analysis of Controlling Leafy Spurge with Sheep*, are available free of charge. Please address your request for additional copies to Carol Jensen, Department of Agricultural Economics, P.O. Box 5636, North Dakota State University, Fargo, ND 58105-5636, (phone 701-231-7441, fax 701-231-7400), E-mail: cjensen@ndsuext.nodak.edu or these documents are available on the world wide web at http://agecon.lib.umn.edu/ndsu.html

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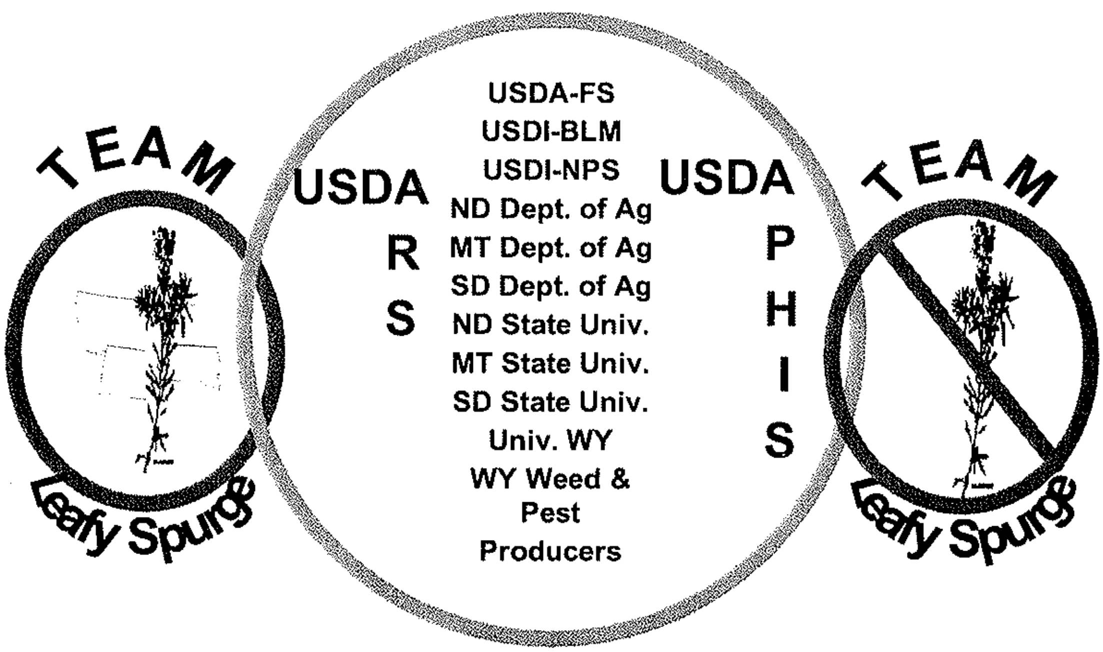

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FEASIBILITY OF A SHEEP COOPERATIVE FOR GRAZING LEAFY SPURGE

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INTRODUCTION

There are three general methods of controlling leafy spurge in the upper Great Plains: 1) chemical, 2) cultural, and 3) biological. Each has limitations on its applicability and effectiveness such that any one method will probably not be practical on all leafy spurge infestations. Use of herbicides is often limited because of environmental and labeling restrictions as well as economic considerations. Tillage and reseeding are often not practical because of the topography of infested areas and economic considerations. Biological control (insects) has provided excellent control in certain conditions but not in others (Bangsund et al. 1997). Another form of biological control, which has been shown to be economical, is grazing with sheep (Bangsund et al. 1999).

Similar to using herbicides to control leafy spurge, the use of sheep grazing does not eradicate the weed; yet it can control the infestation. Sheep grazing of leafy spurge can have a two-fold benefit: 1) decrease the density of the infestation and thereby allow cattle to graze and 2) sheep can directly generate revenue which may provide positive returns. Utilizing a benefit-cost analysis, Bangsund et al. (1999) showed that under season-long grazing strategies with good management (sheep performance), even in less economical situations (low density infestations, small patches of leafy spurge within larger pastures enclosed with new fence), sheep grazing would be economical. Another method of analysis used by Bangsund et al. (1999) was a least-loss analysis, where the economic loss which would occur if leafy spurge was left uncontrolled was compared to losses incurred with control. Thus, even if control results in negative returns, the control method may still be recommended, providing the loss from control is less than the economic loss of allowing the infestation to expand unabated. The only scenarios in which not using sheep grazing controls were better than implementing a sheep grazing enterprise were with poor management, new fencing, and low rangeland carrying capacities.

The use of sheep or goats has been known as an effective method of controlling leafy spurge since the 1930s (Sedivec et al. 1995). However, the majority of ranchers with leafy spurge have not adopted sheep as a potential leafy spurge control tool (Sell et al. 1999b, Sell et al. 1998a, 1998b). A major deterrent to using sheep for controlling leafy spurge is the inability of the ranch operator to provide adequate labor and management for an additional enterprise on the ranch. Ranch operators usually feel that they would not be able to add another job to the work load of the ranch, or they may feel that they can not or do not want to learn the skills necessary to be successful in the production of a different livestock species. Of ranchers recently surveyed in western North Dakota, more than 70 percent felt they did not have the right equipment for sheep, and more than 40 percent indicated they did not have the expertise/knowledge to effectively utilize sheep (Sell et al. 1999b, Sell et al. 1998a, 1998b). Of those ranchers who had leafy spurge, 80 percent grazed only cattle, 18 percent grazed sheep and cattle, and only 2 percent grazed only sheep on their rangeland (Sell et al. 1999b).

This is a summary of an economic feasibility analysis of a cooperatively owned and professionally managed sheep operation for leafy spurge control (Sell et al. 1999a). The objectives of this report were 1) determine the return on investment of the cooperative, 2) determine the proposed structure of the cooperative, and 3) ascertain the amount of capital investment required by members in the cooperative.

The cooperative would be the property of ranchers that have leafy spurge, and sheep from the cooperative would graze the leafy spurge infested rangeland of its members. The flock would be managed as a single unit by a manager hired by the cooperative. A centrally located cooperative, with management strictly dedicated to sheep production, would capture economies of scale in production and exempt the individual ranchers from the burden of learning to manage a new enterprise, while still gaining the benefits of multi-species grazing on leafy spurge infested rangelands. In addition, profits from the sheep operation would accrue to the owners of the cooperatively-owned flock.

PROCEDURES

Three alternative flock management strategies were considered for the cooperative. These were 1) winter lambing, 2) spring lambing, and 3) fall lambing. The primary difference between these alternatives revolves around the timing and length of the lambing season. The necessary equipment, facilities, labor, feed, production, and cooperative member contributions will vary depending on the alternative considered. Each management alternative has unique attributes which will affect its financial performance. Additionally, the logistical challenges facing the distribution and collection of the sheep onto and from the cooperative members' ranches will need to match the requirements associated with the alternatives. After consultation with range scientists, it was determined that the effects of removing the ewes from leafy spurge in August were unknown. It is possible that leafy spurge control would be reduced if the grazing season ended early in the summer. Therefore, the financial feasibility of the fall lambing scenario was not analyzed.

There are also many similarities in the scenarios. Flock size for all scenarios was 5,000 ewes. All replacements were purchased. Terminal sires were used, and all lambs were sold at 125 pounds in each scenario. Ewes for the cooperative were assumed to be western white-faced. These animals are typically a cross of Rambouillet, Columbia, Targhee or some combination of these breeds. They can be expected to weigh 140 to 170 pounds and shear 8 to 10 pounds of wool grading 60's or 62's. Feed costs were adjusted for the differing amounts of weight added to lambs post-weaning depending on the management scenario used. Production coefficients of the winter and spring lambing scenarios are shown in Table 1.

Table 1. Production Coefficients of Winter and Spring Lambing Scenarios

	Winter	**Spring**
Number of Ewes	5,000	5,000
Marketed Number of Lambs	6,000	6,000
Lamb Selling Weight (lbs)	125	125
Market Lamb Price ($/cwt)	$76	$76
Number of Rams	100	100
Ram Purchase Price ($/head)	$200	$200
Cull Ewe Selling Price ($/cwt)	$26	$26
Cull Ram Selling Price ($/cwt)	$13	$13
Ewe Purchase Price ($/head)	$100	$100
Ewe Replacement Rate [1]	20%	20%
Ewe Death Loss Rate	5%	5%
Ram:Ewe Ratio	1:50	1:50
Roughage Used Per Year (tons)	2,650	1,800
Grain Used Per Year (tons)	1,860	965
Hay Price ($/ton) [2]	$51.50	$51.50
Grain Price ($/ton) [3]	$79.80	$79.80
Total Investment Per Ewe [4]	$301.05	$215.71

[1] One thousand replacements purchased and 750 cull ewes sold each year.
[2] Long term average hay prices in North Dakota are $59 for alfalfa and $39 for grass hay. This price represents a weighted average of 60% alfalfa and 40% grass hay (North Dakota Agricultural Statistics Service, various years).
[3] Represents feed barley price per bushel of $1.90.
[4] For a complete description of the facilities and other capital investments in each scenario, please refer to Sell et al. 1999a.

A comparison of the balance sheets for the winter and spring lambing alternatives reveals the total assets required for the spring lambing scenario are nearly 30 percent less than the winter lambing alternative (Table 2). The additional assets required for the winter lambing scenario are based on additional buildings and facilities ($244,000), additional equipment ($58,000), and additional operating capital ($125,000). The additional buildings are predominantly the insulated lambing barn and cold lambing lots (Figure 1). The additional equipment for the winter lambing scenario includes creep feeders, additional feed wagon, and a grinder mixer.

Table 2. Total Assets and Equity Requirements for 5,000 Ewes Under Winter Lambing and Spring Lambing Scenarios

	Winter Lambing	Spring Lambing	Percent Difference
Current Assets	$250,000	$125,000	50.0
Intermediate Assets	718,700	660,700	8.1
Long Term Assets	536,553	292,845	45.4
Total Assets	1,505,253	1,078,545	28.3
Equity Requirement	50%	50%	
Total Equity	$752,627	$539,273	
Member equity/ewe	$150.53	$107.85	

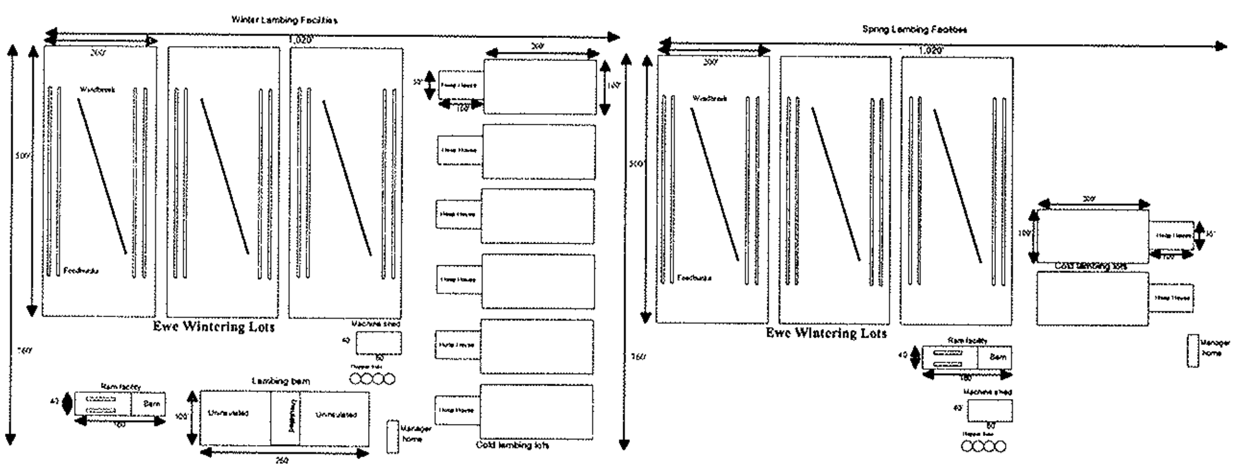

Figure 1. Schematic Drawing Comparing Proposed Facilities for Winter and Spring Lambing Scenarios

Cooperative Members Contribution

A rancher/member's investment in the cooperative accomplishes two things 1) it entitles the member to share in the potential returns/losses resulting from the operation of the cooperative and 2) it requires the member to provide summer pasture according to the number of shares owned. Prospective members to the cooperative would be required to contribute equity and may have to add fencing to their existing pastures. Cooperative member equity investment per ewe was $150 and $108 for the winter and spring lambing scenarios, respectively (see Table 1).

Two alternatives for fencing were analyzed for each scenario, new fence and modified fence. In addition, fencing requirements for each scenario are different because of the different size/age composition of the flocks grazed. Lambs are weaned prior to the grazing season in the winter lambing alternative and do not graze on cooperative member's pastures. The necessary fencing requirements for mature ewes were assumed to be an additional 2 barbed wires added to an existing 3- to 4-wire fence or construction of a new 6-wire fence. For the spring lambing scenario, the lambs graze with the ewes on the leafy spurge pastures. This scenario requires an additional 3 wires added to an existing 3- to 4- wire fence or construction of a new 7-wire fence. Fencing costs (construction, repair, depreciation) were amortized over a 20 year period (Table 3).

Annualized fencing costs incurred by the cooperative member assuming a 50-acre pasture which is 100 percent infested with leafy spurge ranged from $1.59/ ewe for the winter lambing alternative to $1.84/ewe for the spring lambing alternative. Construction of new fencing was generally about five times more costly than modifying an existing fence. For new fence, the average annual cost per ewe was between $0.10 to $0.25/ewe more for the spring lambing scenario than the winter lambing, assuming the infestation size was equal to the pasture size. The smaller the infestation size relative to the pasture size, the greater the fence cost of the spring lambing scenario relative to the winter lambing scenario.

Table 3. Annual Fence Costs per Ewe by Pasture Size and Leafy Spurge Infestation

Pasture Size acres	Fence	Total cost	50	100	150	200	250	300
			Leafy Spurge Infestation (acres) - - - cost / ewe - - -					
Winter Lambing								
50	New	$1,594	$1.59	na	na	na	na	na
	Modify	$286	$0.29	na	na	na	na	na
100	New	$2,197	$2.20	$1.10	na	na	na	na
	Modify	$405	$0.40	$0.20	na	na	na	na
200	New	$3,051	$3.05	$1.53	$1.02	$0.76	na	na
	Modify	$572	$0.57	$0.29	$0.19	$0.14	na	na
300	New	$3,706	$3.71	$1.85	$1.24	$0.93	$0.74	$0.62
	Modify	$701	$0.70	$0.35	$0.23	$0.18	$0.14	$0.12
Spring Lambing								
50	New	$1,844	$1.84	na	na	na	na	na
	Modify	$429	$0.43	na	na	na	na	na
100	New	$2,551	$2.55	$1.28	na	na	na	na
	Modify	$607	$0.61	$0.30	na	na	na	na
200	New	$3,552	$3.55	$1.78	$1.18	$0.89	na	na
	Modify	$859	$0.86	$0.43	$0.29	$0.21	na	na
300	New	$4,320	$4.32	$2.16	$1.44	$1.08	$0.86	$0.72
	Modify	$1,052	$1.05	$0.53	$0.35	$0.26	$0.21	$0.18

Source: Bangsund et al. 1999
na - - not applicable.

RESULTS

Expected annual net income for the baseline winter lambing scenario was a negative $61,000 (Table 4). Net income in this case approximates profitability of the proposed coop. It represents returns after depreciation on buildings, equipment, and the ewe flock. It does not include an opportunity cost for equity capital. The baseline model for the spring lambing scenario generated a positive annual net income of $124,000.

Return on investment for a prospective cooperative member, assuming a 50-acre leafy spurge infestation in a 100-acre pasture, ranged from 16 to 21 percent, depending on whether new or modified fence was used. Return on investment for the winter lambing scenario was negative.

Sensitivity analysis was conducted to determine returns for the cooperative with respect to critical variables, such as lambing percentage and lamb selling price. The lambing percentage is an often used indicator of flock management. The lambing percentage is generally proportional to the number of lambs sold per ewe. The lamb selling price cannot be directly manipulated through management (except through forward contracting or other various marketing schemes); however, assuming there are lambs to sell, it is a critical variable to determine financial viability of the cooperative. To determine the impact of changing these variables, the highest and lowest lamb selling price in the past 10 years was used in the model (North Dakota Agricultural Statistics Service, various years) (Table 4). Also the selling price of lambs and the percentage of lambs sold were changed independently to determine when the cooperative was at a breakeven point with respect to each variable (i.e., there was zero net income and no patronage would be returned to the members).

The high price alternative is the only alternative which provided a positive return (5%) on investment with the winter lambing scenario (Table 4). The feasibility of this alternative seems unlikely as a price level this high was only attained 1 out of the past 10 years. In fact, the lowest lamb price at which the cooperative would breakeven was $84.10/cwt. This price level was only attained 2 out of the past 10 years (North Dakota Agricultural Statistics Service, various years). The percentage of lambs sold per ewe would also have to increase from 120 percent/ewe to 133 percent/ewe. Alternatively, the lowest price at which the spring lambing scenario would operate at breakeven was $59.51/cwt. This price was exceeded in 7 out of the past 10 years (North Dakota Agricultural Statistics Service, various years). The minimum number of lambs sold per ewe for the spring lambing scenario to breakeven is 0.94 lambs/ewe. The North Dakota state average lambs sold per ewe from 1994 through 1998 was 1.26 lambs/ewe (North Dakota Agricultural Statistics Service, various years).

Table 4. Sensitivity Analysis for Winter Lambing and Spring Lambing Scenarios

	Winter Lambing [1]					Spring Lambing [2]				
Income	Expected	Low Lamb Selling Price	High Lamb Selling Price	Lowest Feasible Lambs Sold Per Ewe	Lowest Feasible Price	Expected	Low Lamb Selling Price	High Lamb Selling Price	Lowest Feasible Lambs Sold Per Ewe	Lowest Feasible price
Net income (after Depr.) [3]	($60,728)	($263,228)	$44,272	$1,022	$22	$123,722	($78,786)	$228,714	$214	$39
Net income/ewe	($12.15)	($52.65)	$8.85	$0.20	$0.00	$24.74	($15.76)	$45.74	$0.04	$0.01
Percent earnings/loss returned	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Hypothetical Cooperative Member										
Pasture size	100	100	100	100	100	100	100	100	100	100
Acres of leafy spurge	50	50	50	50	50	50	50	50	50	50
Ewes/shares needed	50	50	50	50	50	50	50	50	50	50
Capital required to purchase shares	$7,526	$7,526	$7,526	$7,526	$7,526	$5,403	$5,403	$5,403	$5,403	$5,403
Investment in additional 'new' fence [4]	$2,197	$2,197	$2,197	$2,197	$2,197	$2,551	$2,551	$2,551	$2,551	$2,551
Investment in additional 'modified' fence [4]	$405	$405	$405	$405	$405	$607	$607	$607	$607	$607
Member equity returned	($607)	($2,632)	$443	$10	$0	$1,237	($788)	$2,287	$2	$0
Return on investment (new fence) [5]	(6.2%)	(27.1%)	4.6%	0.1%	0.0%	15.6%	(9.9%)	28.8%	0.0%	0.0%
Return on investment (modified fence) [5]	(7.7%)	(33.2%)	5.6%	0.1%	0.0%	20.6%	(13.1%)	38.1%	0.0%	0.0%

[1] The expected lamb selling price was $76/cwt, low lamb selling price was $49/cwt, high lamb selling price was $90/cwt, lowest feasible lambs sold/ewe was 1.33, and the lowest feasible lamb selling price was $84.10/cwt.

[2] The expected lamb selling price was $76/cwt, low lamb selling price was $49/cwt, high lamb selling price was $90/cwt, lowest feasible lambs sold/ewe was 0.94, and the lowest feasible lamb selling price was $59.51/cwt.

[3] No opportunity cost charged to member equity.

[4] Assuming a 100-acre pasture.

[5] Investment assumed to include equity capital and fencing material, no charge included for member labor.

The total (over 10 years) and annualized loss of AUMs to cattle from a 50-acre infestation of leafy spurge was determined at carrying capacities ranging from 0.4 to 0.6 AUMs per acre (Table 5). The net returns resulting from the use of a common herbicide treatment program were also calculated (Bangsund et al. 1996). The use of a recommended herbicide treatment program annualized over 10 years will not result in positive returns at carrying capacities from 0.4 to 0.6 AUMs/acre. However, the economic loss which results with the use of this herbicide treatment program will be less than the loss from not treating the leafy spurge at carrying capacities of more than 0.5 AUMs/acre.

Annual net returns (calculated at $15/AUM for AUMs gained, less annualized cost of grazing, plus patronage) resulting from using the spring lambing scenario in a 100-acre pasture, with a 50-acre leafy spurge infestation at various carrying capacities were calculated (Table 5). Assuming the cooperative does not pay any patronage (operates at breakeven), the annual net return from grazing the sheep would be negative; however, the resulting net loss would be less than not treating the infestation at carrying capacities of 0.5 AUMs/acre and higher. If the cooperative returns $12.00/ewe or $600 annually, the net returns are positive. In this case, the returns are the value of the AUMs which are gained (valued at $15/AUM) as a result of grazing the sheep on leafy spurge infested rangeland. The annual net returns increase as the carrying capacities are increased. If the cooperative generates returns equal to expectations (see Table 5), then the annual net returns are increased by more than $600 for the 50-acre infestation.

Table 5. Comparison Annualized Costs and Returns Over 10 years for Uncontrolled, Using Herbicides, and Grazing Sheep on a 50-Acre Leafy Spurge Infestation

Uncontrolled Infestation [1]

AUMs/Acre	Annual Average AUMs Lost	Value Lost AUMs
0.4	20.34	($305)
0.5	25.39	($381)
0.6	30.47	($457)

Herbicide Application [2]

AUMs/Acre	Average Annualized Cost	Value of Gained AUMs	Annual Net / 50 acres
0.4	$565	$183	($382)
0.5	$565	$229	**($336)**
0.6	$565	$275	**($290)**

Sheep Grazing (zero patronage)

AUMs/Acre	Average Annualized Grazing Cost [3]	Value of Gained AUMs	Patronage	Annual Net/ 50 acres [4]
0.4	$600	$184	$0	($416)
0.5	$600	$230	$0	($370)
0.6	$600	$276	$0	($324)

Sheep Grazing (annual patronage equals average investment)

AUMs/Acre	Average Annualized Grazing Cost [3]	Value of Gained AUMs	Patronage [5]	Annual Net/ 50 acres [4]
0.4	$600	$184	$600	**$184**
0.5	$600	$230	$600	**$230**
0.6	$600	$276	$600	**$277**

Sheep Grazing (expected patronage)

AUMs/Acre	Average Annualized Grazing Cost [3]	Value of Gained AUMs	Patronage [5]	Annual Net/ 50 acres [4]
0.4	$600	$184	$1,237	**$821**
0.5	$600	$230	$1,237	**$867**
0.6	$600	$276	$1,237	**$914**

Note: Annual net/50 acres in **BOLD** represent returns which are "least-loss" (loss is less than loss of not treating infestation).

[1] Assumed patch expansion of 2 radial feet per year, and AUMs valued at $15, initial patch density 30 percent. A 30 percent (80-120 stems per square meter) patch density translates into essentially no cattle grazing within the patch.

[2] Assumed $5/acre application cost and chemical treatment program annualized over 10 years of

.25 lb/acre of Picloram and 1.0 lb/acre of 2,4-D. Application and chemical costs equaled $18.83/acre in treatment year. Infestation was treated 6 out of 10 years for an annualized treatment cost of $11.30/acre.

[3] Annualized grazing cost is comprised of total equity invested in cooperative ($5,393) plus modified fencing costs for 100 acre pasture ($607) amortized over 10 years plus equals $600.

[4] Equals annual avg. AUMs gained (@$15/AUM) minus annual avg. cost of grazing, plus patronage. Returns would be lower with new fencing.

[5] Annual patronage is $12.00/ewe (i.e., $600/50 shares; patronage equal to original investment).

[6] Annual patronage is $24.74/ewe (i.e., $1,237/50 shares; expected results).

CONCLUSION

This report presents the feasibility for a 5,000 ewe flock cooperative whose members would use the sheep to control leafy spurge. Three scenarios were initially investigated 1) winter lambing, 2) spring lambing, and 3) fall lambing. The fall lambing scenario was determined to be infeasible because of logistics associated with gathering and transportation of pregnant ewes and lack of grazing pressure on leafy spurge throughout the grazing season.

The total capital investment per ewe for the winter lambing scenario was more than the spring lambing scenario - - $301 and $216, respectively. The expected net income generated by the winter lambing scenario was negative. The minimum break-even lamb selling price or lambs sold per ewe for the winter lambing scenario was $84.10/cwt and 1.33, respectively. The spring lambing scenario returned $124,000 annually. The minimum breakeven lamb selling price or lambs sold per ewe for the spring lambing scenario was $59.51/cwt and 0.94, respectively. The expected return on investment (50% equity) for cooperative members with the spring lambing scenario, assuming a 50-acre leafy spurge infestation in a 100-acre pasture and new fence, was 16 percent. Return on investment with modified fence increased to 21 percent. While these returns are not a guarantee of success for the spring lambing alternative, they do provide an indication of the potential that such a cooperative may have.

For large infestations (more than 50 acres) it is difficult, if not impossible, to find a control program which will generate positive returns to control (except biological control). Often a producer's only recourse is to simply "limit the losses" of the infestation. Returns/losses from no control, recommended herbicide control, and grazing sheep from the spring lambing cooperative were compared. If the cooperative generates slightly less than ½ of expected returns, the cooperative members can expect positive returns from controlling leafy spurge with sheep. However, if the cooperative does not generate a positive return, then the producer is better off to use herbicides or not attempt to control the infestation.

There are a number of limitations of this study. The model parameters such as labor requirements, conception rates, lambing percentage, variable and fixed input costs, ewe and ram selling and purchasing prices were fixed. The value of these coefficients will likely change over time, and this impact was not investigated. This study only analyzed the performance of a large scale cooperative. There may be situations where a larger cooperative may be able to capture greater economies of scale or alternatively a smaller scale cooperative is more practical given the logistical characteristics of leafy spurge infestations within a region. Sheep stocking rates were not changed based upon rangeland carrying capacities. Labor availability was not assumed to be a constraint. This may or may not be the case given the current record low unemployment rates in North Dakota.

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Effect of field pea (*Pisum sativum*) replacement of corn on lamb performance in finishing diets. E. R. Loe, M. L. Bauer, G. P. Lardy, P. T. Berg, and B. L. Moore.
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Introduction

Field peas have been shown to effectively replace corn and soybean meal in growing and finishing diets for calves (Poland and Landblom, 1996; Birkelo, 1998) and lambs (Poland and Landblom, 1998). NDSU research reported in the 1999 Western Dakota Sheep Day Report showed that field peas were greater in net energy compared with corn in lamb finishing diets.

64,000 acres of field peas were planted in North Dakota in 1999, down from a high of 102,849 in 1998. Crude protein content of field peas range from 14 to 28.5%. Published energy values for field peas are 87% TDN, 98 Mcal NE_m/cwt (net energy for maintenance/cwt), and 67 Mcal NE_g/cwt (net energy for gain/cwt).

Summary

Five diets (Table 1) were fed to Hampshire cross ram lambs to determine the energy value of field peas in lamb finishing diets. In diets one through four, peas replaced 0, 15, 30, and 45% of the corn, and in the fifth diet (45-no-SMB) peas replaced 39% of the corn and all of the soybean meal (SBM). Inclusion of peas did not affect ($P > .15$) dry matter intake (DMI), average daily gain (ADG), or feed efficiency (Table 2). Lambs were more efficient ($P = .10$) when fed 45-no-SBM compared with lambs eating 45% peas. Leg conformation and carcass conformation changed quadratically ($P = .05$) with addition of peas. There were no other carcass characteristics (Table 3) affected by treatment ($P > .10$). The calculated net energy for maintenance (NE_m) and net energy for gain (NE_g) for field peas were 100 and 69 Mcal/cwt, respectively which is 3% greater than corn.

Materials and Methods

One hundred ram lambs (86.0 ± .4 lb initial weight) fed for 63 days were blocked by weight and allotted to one of five dietary treatments (5 pens/treatment). Lambs were housed at the NDSU Animal Research Center barns. Treatments one through four were designed to have peas replace 0, 15, 30, and 45% of the corn and contained 75% dry-rolled corn (DRC) or dry-rolled peas and 6% SBM. In the fifth treatment (45-no-SBM) peas replaced corn and all SBM. Treatment five contained 45% dry-rolled peas and 36% DRC.

All diets contained 10% alfalfa, 5% CSB, .8% feather meal, .2% blood meal, and 3% supplement. Feathermeal and bloodmeal were included as dietary sources of by-pass protein. Diets were formulated to contain a minimum 14.8% CP, .7% Ca, .43% P, 1.22% K, 1.51 Ca:P, and 25 g lasalocid/Ton.

Feed offered was adjusted daily prior to feeding. Each pen had access to an indoor and outdoor run and fresh water. Initial and final weights were an average of two consecutive day weights. Average daily gain, dry matter intake, and feed efficiency were measured. Carcass characteristics of all lambs were taken at slaughter, however, hot carcass weights were not gathered due to a mix up at the slaughter facility.

Results and Discussion

Inclusion level of field peas did not affect ($P > .15$) any measure of performance (Table 1), however, lambs fed 45-no-SBM were more efficient than lambs fed the 45% pea diet ($P = .10$). Leg conformation and carcass conformation changed quadratically ($P = .05$) with addition of peas. There were no other carcass characteristics affected by treatment ($P > .10$).

Calculated dietary NE_m and NE_g (Table 4) were greater for 45-no-SBM compared to 45% peas ($P = .05$). No other dietary effects ($P > .24$) on NE_m or NE_g occurred. Based on lamb performance, field peas have a calculated NE_g that is 3% greater than corn (69 vs 67 Mcal/cwt) when fed to feedlot lambs.

Field peas are higher in ruminally degraded intake protein (DIP) than corn (78 vs 45% DIP as a percent of CP, respectively). Calculated DIP for the 0, 15, 30, 45, and 45-no-SBM treatments were 8.9, 10.7, 12.5, 14.3, and 12.6%, respectively. None of the treatments should have been limited by ruminal protein.

Cost per hundredweight of gain (Table 5) was analyzed. Prices for corn, field peas, and SBM were $2.00/bu, $3.00/bu and $130/ton, respectively. Cost of gain was calculated by dividing price per hundredweight of feed by gain:feed (feed efficiency). There was a linear increase ($P > .01$) in cost of gain as inclusion level of field peas increased. Compared with 45% peas lambs eating the 45-no-SBM diet had a lower cost of gain ($P = .02$). Decrease in cost of gain is explained by the increase in lamb efficiency and replacement of SBM ($.065/lb) with field peas.

Conclusions

Field peas and corn are similar in net energy content. Field peas can effectively replace corn and SBM in lamb finishing diets based on the improved feed efficiency. Using the prices reported in this report, however, there is an increase in cost per hundredweight of gain with the inclusion of field peas. The NRC under values the energy content of field peas when used in high-grain diets.

Table 1. Diet composition (% Dry matter basis)

Ingredient	Unit	Dietary Treatment (% Field Peas)				
		0	15	30	45	45noSBM
DRC	%	75	60	45	30	36
Field Pea	%	0	15	30	45	45
Alfalfa	%	10	10	10	10	10
CSB	%	5	5	5	5	5
SBM	%	6	6	6	6	0
FM	%	.8	.8	.8	.8	.8
BM	%	.2	.2	.2	.2	.2
Supp.	%	3	3	3	3	3
Calculated composition						
CP	%	14.8	16.5	18.2	19.9	17.5
DIP[a]	%	5.9	5.8	5.7	5.6	4.9
UIP[b]	%	8.9	10.7	12.5	14.3	12.6
MP:ME		22.2	23.61	24.09	27.06	23.10

[a] Rumen degradable intake protein

[b] Rumen undegradable intake protein

Table 2. Effect of treatment on feedlot performance (dry matter basis)

Item	Unit	Dietary Treatment (% Field Peas)					
		0	15	30	45	45noSBM	Error
Initial wt	lb	85.9	86.3	86.0	86.0	85.9	.4
Final wt	lb	134.8	137.1	136.7	132.9	136.9	2.0
DMI	lb/day	3.49	3.65	3.45	3.47	3.44	.11
ADG	lb/day	.78	.81	.81	.74	.81	.03
Feed/Gain[a]		4.48	4.49	4.29	4.61	4.22	–

[a] Feed/Gain calculated as Gain/Feed. Feed/Gain is a reciprocal of Gain/Feed.

Table 3. Effect of treatment on carcass characteristics

Item	Unit	Dietary Treatment (% Field Peas)					
		0	15	30	45	45noSBM	Error
REA	in^2	2.31	2.44	2.47	2.48	2.53	.09
Backfat	in	.16	.15	.16	.13	.14	.02
Bodywall	in	.85	.77	.77	.82	.86	.04
YG		4.38	4.17	4.35	3.70	4.08	.43
Leg[a]		11.1	11.5	11.2	11.0	11.1	.1
Carcass[b]		11.0	11.4	11.0	10.8	11.0	.1

[a] Leg conformation

[b] Carcass conformation

Table 4. Effect of treatment on calculated dietary net energy

Item	Unit	Dietary Treatment (% Field Peas)					Error
		0	15	30	45	45noSBM	
NE_m[a]	Mcal/cwt	105	105	109	101	110	3
NE_g[a]	Mcal/cwt	73	73	77	70	78	3

[a] NE_m and NE_g were calculated from lamb performance

Table 5. Effect of treatment on cost of gain

Item	Unit	Dietary Treatment (% Field Peas)					Error
		0	15	30	45	45noSBM	
Diet cost	$/cwt	4.83	5.06	5.30	5.54	5.36	
Cost of gain	$/cwt	21.81	22.85	22.87	25.84	22.92	.81

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Addition of rumen degradable and undegradable protein to corn-based lamb finishing diets. E. R. Loe, M. L. Bauer, G. P. Lardy, P. T. Berg, and B. L. Moore.
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Summary

This trial was conducted to evaluate if metabolizable protein (MP) limited lamb performance when fed a corn-based diet. Treatments (Table 1) were arranged in a 2 x 2 factorial design; with or without added DIP and UIP. Lambs fed UIP had heavier final weights (P = .009), gained more rapidly (P = .007), and were more efficient (P = .07) compared with DIP fed lambs. A DIP × UIP interaction occurred (P = .08) for REA where addition of UIP alone increased REA compared with diets without UIP addition. Dietary NE_m and NE_g were greater (P = .09) for diets containing added UIP.

Introduction

Metabolizable protein (MP) is the combination of ruminal undegradable intake protein (UIP; protein that escapes rumen microbial breakdown) and bacterial crude protein that enters the small intenstine and can be broken down and absorbed by the animal. The metabolizable protein requirements of lambs have not been addressed and need to be established.

Addition of a rumen degradable protein (DIP; protein that is broken down by the ruminal microorganisms) source in high-corn cattle finishing diets shows an increase in performance. However, based on NDSU research replacement of corn with a grain higher in DIP such as field peas demonstrates that lambs may not be limited in ruminal protein when consuming corn-based high-grain diets.

Materials and Methods

Eighty crossbred Hampshire ram lambs (85.8 ± .7 lb initial weight) were blocked by weight and allotted randomly to dietary treatment. Lambs were housed at the NDSU Animal Research Center barns. There were 5 pens/treatment. Rumen degradable intake protein sources were SBM and urea; whereas, UIP sources were feathermeal and bloodmeal. Main effects of DIP, UIP, and their interactions were tested. Lambs were fed for 63 days.

Diets were formulated to contain a minimum .7% calcium, .43% phosphorous, 1.22% potassium, 1.51 calcium:phosphorous, and 25 g lasalocid/Ton. Feed offered was adjusted daily prior to feeding. Each pen had access to an indoor and outdoor run and fresh water.

Initial and final weights were an average of two consecutive day weights. Average daily gain (ADG), dry matter intake (DMI), and feed efficiency were measured. Carcass characteristics of all lambs were taken at slaughter, however, hot carcass weight was not gathered due to a mix up at the slaughter facility.

Results

Performance measurements (Table 2) were DMI, ADG, and feed efficiency. Lambs fed UIP had heavier final weights (P = .009), greater rates of gain (P =.007), and were more efficient (P = .07) compared with lambs fed DIP. There was a DIP × UIP interaction (P = .08) for REA (Table 3). Lambs fed UIP had larger REA than lambs fed diets without UIP addition. Other carcass characteristics were not affected (P > .10) by treatment.

Dietary NE_m and NE_g (Table 4) were calculated from lamb performance and were greater (P = .09) for diets containing added UIP.

Conclusions

The lack of response to the addition of DIP, demonstrated that DIP does not limit lamb performance and based on lamb response to added UIP, lambs with the potential to gain .77 lb/day or greater are limited by MP in corn-based finishing diets.

Table 1. Diet Composition (% DM basis)

		Dietary Treatments (% DM basis)			
		-UIP		+UIP	
Item	Unit	-DIP	+DIP	-DIP	+DIP
DRC	%	75	71	74	70
Alfalfa	%	10	10	10	10
CSB	%	5	5	5	5
SBM	%	6.00	10.51	3.78	8.23
Urea	%	.20	.26	.19	.26
Feather meal	%	.80	.11	3.04	2.34
Blood meal	%	.20	.03	.76	.59
Supplement	%	2.80	3.09	3.23	3.58
Crude Protein	%	14.8	16.9	16.2	18.3
DIP[a]	%	8.9	11.0	8.9	11.0
UIP[b]	%	5.9	5.9	7.3	7.3
MP:ME[c]		22.2	22.2	24.5	23.6

[a] Rumen degradable intake protein
[b] Rumen undegradable intake protein
[c] gram metabolizable protein/Mcal metabolizable energy

Table 2. Effect of treatment on feedlot performance

		Dietary Treatments (% DM basis)				
		-UIP		+UIP		
Item	Unit	-DIP	+DIP	-DIP	+DIP	Error
Initial wt	lb	85.9	85.3	85.7	86.0	.6
Final wt	lb	134.9	133.8	142.3	138.2	2.0
DMI	lb/day	3.48	3.41	3.70	2.86	.13
ADG	lb/day	.77	.77	.90	.84	.02
Feed/Gain[a]		4.48	4.42	4.07	3.95	—
REA	in^2	2.31	2.34	2.59	2.44	.07
Backfat	in	.88	.74	.85	.96	.07
Bodywall[b]	in	4.74	4.54	4.94	4.86	.53
YG		4.38	3.77	4.38	4.78	.31
NE_m[c]	Mcal/cwt	105	106	112	116	5
NE_g[c]	Mcal/cwt	74	75	80	83	4

[a] Feed/Gain was calculated as Gain/Feed. Feed/Gain is a reciprocal of Gain/Feed.
[b] Bodywall is a measurement of total body lean. Lower number corresponds with leaner carcass.
[c] NE_m and NE_g are calculated from lamb performance

Effects of FSH treatment in seasonally anestrous ewes on egg production, retrieval, and quality for use in *in vitro* fertilization procedures.

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INTRODUCTION

Through the use of assisted reproductive technology (ART), we will be able to extend the use of genetically superior animals, and perhaps increase the number of offspring. These technologies include such procedures as estrus synchronization, superovulation, artificial insemination, embryo transfer, *in vitro* fertilization (IVF), and cloning. Because they exhibit seasonal breeding and multiple ovulations, sheep have a tremendous potential for improvement and manipulation of reproduction with the use of ART. Most sheep normally exhibit estrous cycles and mate during late summer, fall, and early winter. During winter, spring, and early summer they exhibit anestrous, and thus, are reproductively inactive. Reproductive performance of sheep, in some cases, can be maximized by utilizing this anestrous period or non-breeding season. Manipulations to maximize reproductive performances during seasonal anestrous include hormonal stimulations and estrous synchronization. However, many improvements are still needed to enhance the reproductive efficiency of ewes during seasonal anestrous.

Very little research has been conducted to study out-of-season effects on oocyte (egg) quality for *in vitro* fertilization. IVF requires a large number of eggs collected from ewes. The method of inducing follicular development with follicle stimulating hormone (FSH) has been widely used (Gordon, 1997, Cognie, 1999). The ewe naturally releases FSH from the anterior pituitary gland in response to gonadotropin releasing hormone (GnRH) to promote follicular development during the breeding season. When injected into ewes for two or more days at regular intervals, FSH usually promotes development of a large number of follicles on each ovary during the breeding season and out-of-season (Jablonka-Shariff, 1994, 1996; Gordon, 1997). Synchro-Mate-B (SMB; a synthetic progestogen) is often used to synchronize estrus among animals. However, it also helps to stimulate the animals to begin their reproductive cycles during the non-breeding season. The aim of this study was to determine the effects of FSH and Synchro-Mate-B on the number of follicles, the recovery and quality of oocytes, and the ability of these oocytes to fertilize *in vitro* (in the laboratory) when oocytes were collected from ewes during seasonal anestrous.

MATERIALS AND METHODS

Seasonally anestrous ewes of mixed breeds were used for this experiment during the winter and spring of 1999. Half of the ewes were implanted with Synchro-Mate-B (½ implant; Merial Limited, Athens, GA) and left in place for 14 days. SMB contains norgestomet, a potent synthetic progestin that can stimulate reproductive hormone cycles upon its removal in anestrous ewes. On day 14 (day 0 = day of SMB implantation), SMB implants were removed through a small incision made in the skin. The other half of the ewes were not implanted with SMB.

Induction of multiple follicular growth and oocyte collection

Ewes (n = 49) were randomly assigned to three groups which were given one of three treatments: no treatment (control, n = 12), FSH injected for two days (2D, n = 21) or 3 days (3D, n = 15). Beginning on the morning of Day 12 (3D) or Day 13 (2D) after SMB implantation, ewes received twice daily (morning and evening) intramuscular injections of FSH (porcine FSH with 10% luteinizing hormone; Sioux Biochemical, Sioux Center, IA). Injections were as follows: Day 1, 5 units (1.0 ml)/injection; Day 2, 4 units (0.8 ml)/injection; Day 3, 3 units (0.6 ml)/injection (total dose: 2 day treatment = 18 units; 3 day treatment = 24 units). SMB was removed on Day 14 and a laparotomy was performed on Day 15 at 15 hours after the removal of the SMB implant, to count follicles and retrieve oocytes.

At laparotomy, the ovaries were exteriorized and the number of follicles were counted on each ovary. In addition, for each follicle, the surface diameter was measured and follicles were classified as <3mm (small), 3-8mm (medium), and >8mm (large) before oocyte collection. An ovariectomy was performed and oocytes were collected in the laboratory. Oocytes were then collected by aspiration using a 22-gauge 1-inch needle and a syringe containing approximately 0.2 ml of collection media that consists of TCM-199 (Sigma, St. Louis, MO), 2% heat inactivated fetal bovine serum (FBS; Gibco, Gaithersburg, MD), heparin (Sigma), and penicillin/streptomycin (Watson et al., 1994). Each collected follicle was washed/flushed three times with the collection media. The media and follicular fluid from each follicle was emptied into petri dishes.

By using a stereoscope, each dish was searched and the recovered oocytes were transferred to a petri dish with fresh collection media at which point all oocytes from individual ewes were combined. Oocytes were then evaluated based on morphology and categorized as healthy or atretic according to Thompson et al. (1995). All oocytes were washed three times in maturation media before being transferred into stabilized maturation media (TCM-199, 10% FBS, ovine FSH [oFSH-RP-1; NIAMDD-NIH, Bethesda, MD], ovine LH [oLH-26; NIADDK-NIH], estradiol [Sigma], glutamine [Sigma], sodium pyruvate [Sigma], and penicillin/streptomycin; Watson et al., 1994).

In vitro fertilization of collected oocytes

Oocytes collected from ewes were subjected to *in vitro* fertilization and evaluated for fertilization rates. The oocytes were matured for 21-24 hours at 39 C, 5% CO_2, and 95% air. After maturation procedures, the oocytes were again evaluated for health based on morphology. Oocytes classified as healthy were separated and used for in vitro fertilization (IVF). The cumulus cells were removed by a 1% hyaluronidase (Type I-S; Sigma) treatment and the healthy oocytes were transferred to stabilized fertilization media, consisting of synthetic oviductal fluid (SOF; Tervit et al., 1972) and 2% heat inactivated sheep serum collected from sheep on day 3 of the estrous cycle (O'Brien et al., 1997).

Frozen semen, which was pooled from 4 NDSU rams, was thawed and viable sperm were separated using the swim up technique (Yovich, 1995). In the swim up technique, the healthy and viable sperm from a semen fraction swim into the media (Modified Sperm Washing Medium, Irvine Scientific, Santa Ana, CA) which lays on top of the thawed semen pool. This media containing the motile healthy sperm is then centrifuged, counted and used for in vitro fertilization. 0.5-1.0 x 10^6 sperm/ml were added to the oocytes (up to 20/500 µg/well). The oocytes were incubated with the sperm for 17-20 hours at which time the embryos were washed three times with culture media without glucose (SOF supplemented with BSA, glutamine, MEM amino acids, BME amino acids [Sigma], and penicillin/streptomycin; Catt et al., 1997). The dishes were evaluated, 48-60 h after adding sperm to the oocytes, to determine the number of cleaved oocytes (i.e., embryos).

Statistical analysis

All data is reported as means per ewe ± the standard errors.

Data was analyzed as a 2x3 factorial with SMB and FSH-treatments as the main effects. Numbers of follicles and oocyte numbers and percentages of matured oocytes for non-treated and FSH-treated ewes were analyzed by using the general linear models (GLM) procedure of the Statistical Analysis System (SAS, 1985). When the F-test was significant, differences between specific means were evaluated using t-tests. Relationships between treatments were evaluated using least squares difference (LSD).

RESULTS

Ewes treated with Synchro-Mate-B had similar ($P > 0.05$) numbers of follicles, numbers of oocytes, and oocyte health when compared to ewes that did not receive SMB. Therefore, data were combined among SMB implanted and non-implanted ewes.

The number of small, medium, and large follicles in non-treated and FSH-treated ewes during the non-breeding season are presented in Table 1.

Table 1: Number of small, medium, and large follicles in non-treated and FSH-treated ewes during seasonal anestrous.

		Number of follicles			
Treatment	n	<3mm	3-8mm	> 8mm	Total
None	13	5.5±0.99[a,b]	1.4±0.29[a]	0.08±0.08	6.92±0.92[a]
2D FSH	21	6.9±1.44[a]	11.8±1.12[b]	0	18.67±1.93[b]
3D FSH	15	3.1±0.90[b]	14.5±2.41[b]	0.4±0.4	18.00±2.58[b]

[a, b,] - means ± SEM differ within a column, $P < 0.05$.
n - number of ewes.

FSH treatment increased ($P < 0.01$) the number of medium and total number of follicles, but did not affect the number large follicles present. The non-treated ewes and the ewes treated with

FSH for 2 days had a greater number ($P < 0.05$) of follicles that measured less than 3 mm. Table 2 presents the number of eggs collected from small, medium, and large follicles from non-treated and FSH-treated ewes during seasonal anestrous.

Table 2. Number of oocytes recovered from small, medium, and large follicles for non-treated and FSH-treated ewes during seasonal anestrous.

		Number of oocytes recovered			
Treatment	n	<3mm	3-8mm	>8mm	Total
None	13	4.3 ±0.94	1.2±0.32^{a}	0.08±0.08	5.62±0.98^{a}
2D FSH	21	4.8±1.07	10.6±1.09^{b}	0	15.4±1.73^{b}
3D FSH	15	2.2±0.76	12.8±2.13^{b}	0.3±0.3	15.3±2.28^{b}

$^{a, b}$ - means ± SEM differ within a column, P<0.05.
n - number of ewes.

FSH-treatment increased ($P < 0.05$) the number of eggs recovered from medium sized and total follicles. However, FSH-treatment did not affect the number of eggs recovered from small and large follicles.

Table 3 presents the recovery rate, number and percentage of healthy oocytes recovered from non-treated and FSH-treated ewes during seasonal anestrous.

Table 3. Recovery rate, and percentages of healthy and atretic oocytes for non-treated and FSH-treated ewes during seasonal anestrous.

Treatment	n	Total recovery rate (%)	# of healthy oocytes	% healthy oocytes
None	13	79.5±9.1	4.62±0.76^{a}	84.2±4.8
2 day FSH	21	81.6±3.3	13.2±1.5^{b}	86.7±2.6
3 day FSH	15	84.6±3.3	11.9±1.8^{b}	80.1±4.3

$^{a, b}$- means ± SEM differ within a column , P<0.05.
n - number of ewes.

The recovery rate of oocytes and the percent of healthy oocytes did not differ between non-treated and FSH-treated ewes. However, the number of healthy oocytes was greater ($P < 0.05$) for the FSH-treated ewes than the non-treated ewes.

Fertilization rate for this study was low. Ewes treated with FSH for 2 and 3 days only had 6% fertilization and the non-treated ewes had a 14 % fertilization rate.

DISCUSSION

Assisted reproductive technologies are powerful tools in animal industry for genetic improvement and also for enhancing reproductive efficiency. However, in the sheep industry these technologies are less than optimal for use during seasonal anestrous. Improving breeding rates during seasonal anestrous would contribute to increasing reproductive efficiency in ewes, as well as extend the use of these valuable techniques.

In the present study, follicular growth was induced in seasonally anestrous ewes by FSH. This study is similar to an earlier study conducted during the breeding season using the same treatment groups (Stenbak et al., 1999). In the present study SMB did not have any effect on follicular development, oocyte retrieval, and the health of the oocytes. FSH induced follicular development in SMB and non-implanted ewes. The total number of follicles from ewes treated with FSH for 2 days and 3 days was 18. In addition, non-treated ewes had the smallest number of follicles with an average of 7 follicles per ewe. In an earlier study conducted during the breeding season, ewes treated with FSH for 2 days exhibited 16 total follicles, whereas, ewes treated with FSH for 3 days had 18 total follicles per ewe and non-treated ewes exhibited 8 total follicles (Stenbak et al., 1999). These data support other reports that FSH treatments for ART are an effective way to induce follicular development in ewes (Jablonka-Shariff et al., 1994, 1996; Gordon, 1997). From this study, it appears that there is no seasonal effect in the follicular response to FSH in ewes.

Understanding how superovulation techniques affect the quality of oocytes will lead to improved ART. The number of healthy oocytes was higher in FSH-treated ewes than in non-treated ewes. However, the percent of healthy oocytes after maturation was not significantly different among treatment groups. The number of healthy oocytes and the percent of healthy oocytes is similar to the previous experiment that we conducted during the breeding season (Stenbak et al., 1999).

Unfortunately, the fertilization rates in this study were very low (only 7%). Other studies have shown that *in vitro* fertilization is possible out-of-season (Pugh et al., 1991). However, the fertilization rate of oocytes collected out-of-season was only 53%, whereas fertilization rates during the breeding season range from 68-80% (Pugh et al., 1991; Slavik, et al.,1992; Ledda, et al., 1997; O'Brien, et al., 1996,1997; Watson, et al., 1994). The ewes in the Pugh et al. (1991) study received similar FSH treatment as our study. However, contrary to our study, their experiment was performed on Coopworth ewes, a mix of Border Leicester and Romney (New Zealand), where seasonal affects are negligible. Most data from the present study were consistent with our previous study conducted during the breeding season in which we obtained approximately 70% *in vitro* fertilization rates (Stenbak et al., 1999). The semen for both the present and the previous experiments were from the same pool, so the low fertilization rates found in the present study probably was not due to poor semen quality, but rather due to seasonal effects.

In an effort to determine why IVF rates were so low in the present study, we implanted SMB into 6 ewes for 14 days. After removal of SMB, the sheep were allowed to cycle before they were re-implanted for another 14 days. This was done to mimic a normal estrous cycle prior to oocyte collection. The sheep received 2 days of FSH as described earlier and oocytes were collected and processed as in the above study. We found that the fertilization rate in these ewes was 28%, which is greater ($P < 0.068$) than the 7% found in the ewes injected with FSH for 2 days in the above study. This is still lower than the results in the Pugh et al. (1991) study. It does indicate that prior treatment with SMB to mimic estrous cycles may be necessary for *in vitro* fertilization. However, it also shows that much work is needed to improve IVF rates of seasonally anestrous oocytes. Other techniques, besides SMB implants, are also available to aid in inducing the estrous cycle during seasonal anestrous. Such techniques include light manipulation, melatonin supplementation, progestogen and PMSG treatments (Gordon, 1997).

The results of this study will ultimately lead to improved and efficient methods for obtaining large numbers of high quality oocytes and embryos for embryo transfer programs. Improvement in these techniques will enhance the overall efficiencies in the sheep industry during the breeding season and out-of-season.

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Effects of Gonadotropin Treatment on Incidence of Estrus and Pregnancy Rate in Ewes Synchronized with Synchro-Mate-B (SMB) and Subjected to Laparoscopic Artificial Insemination (LAI) During the Breeding Season

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INTRODUCTION

Animal agriculture must become more efficient to keep up with the ever growing demands for food and fiber in a competitive market. The sheep industry has the opportunity to fulfill part of this need. However, improvement in sheep production technologies have not been greatly utilized. Parker et. al. (1983) reported that fewer than 15% of commercial breeding ewes gave birth to more than one lamb. In 1998, the national average of number lambs born per ewe per year was 1.1, and the number of lambs weaned per ewe was less than one (USDA Economics and Statistics System, 1999).

Artificial insemination (AI) is a useful technique for improving reproductive performance in ewes as well as providing a means to introduce new genetics. Many different techniques have been used for AI; however, direct uterine insemination with the aid of a laparoscope has become the "industry standard" for AI in ewes because of the relatively high conception rates compared to other techniques (Gourley and Riese, 1990). Laparaoscopic AI (LAI) requires the use of estrus synchronization and timed insemination techniques, for LAI otherwise would be virtually impossible from a labor stand-point.

Although many techniques have been used for estrus synchronization in ewes (Wildeus, 1998; Windsor, 1994; Gordon, 1997), perhaps the most widely used technique is that reviewed by Gourley et. al. (1990). This technique uses a synthetic progestin implant to synchronize estrus along with pregnant mare's serum-gonadotropin (PMSG) to stimulate ovarian activity. Insemination is conducted at 58 - 60 hr after removing implants. However, conception rates can still vary widely, most likely due to variation in individual ovarian response to falling progestin levels and response to PMSG. An exhaustive search of the literature could not reveal why PMSG is used for LAI procedures. This study will test the importance of using PMSG at the time of implant removal. In addition, this study is being conducted to determine if the addition of gonadotropin releasing hormone (GnRH) 36 hrs after implant removal will improve conception rates presumably by tightening the time of ovulation among individual ewes. Preliminary data (Redmer, 1998; unpublished observations) has shown that the use of GnRH in the synchronization procedure described by Gourley and Riese (1990) resulted in an 80% conception rate. According to Murdoch et al. (1998), ewes will ovulate 24 hr after the administration of GnRH.

Data conducted from this study will provide valuable insight into improving the procedures used for timed-insemination in ewes.

MATERIALS AND METHODS

Purebred Hampshire and Montadale ewes were implanted with SMB for 14 days and randomly assigned to one of four gonadotropin treatments (n=20/group) in a 2 x 2 factorial design (+/- PMSG and +/- GnRH). Ewes received i.m. injection of pregnant mare's serum-gonadotropin (PMSG; Folligon, Intervet, Whitby, Ontario; 400 IU) or vehicle (V1) at SMB removal and gonadotropin releasing hormone (GnRH; Cystorellin, Merial, Athens, GA; 25 μg) or vehicle (V2) at 36 hr after SMB removal. Vasectomized rams with markers were penned with the ewes at SMB removal and estrous activity was recorded. All ewes were subjected to LAI at 58-60 hr after SMB removal. Intact rams with markers were turned in with the ewes 10 days after LAI and rebreeding was recorded. Ewes were evaluated for pregnancy 35-40 days after LAI by real-time ultrasonography. LAI was conducted in the months of August and September.

RESULTS

Data regarding synchronization of estrus, estrous return rates, and pregnancy rates are presented in Table 1. No differences were observed among treatments (P>0.10; chi-square test) for any of the variables measured.

Table 1. Percentages in estrus, rebred, and pregnant for ewes synchronized with Synchro-Mate-B and then subjected to laparoscopic artificial insemination following various gonadotropin treatments during the breeding season.*

Treatment	n	Ewes in Estrus† (%)	Ewes Rebred (%)†	Pregnancy Rate (%)†
V1/V2	19	89.5	52.6	47.4
V1/GnRH	20	70.0	40.0	50.0
PMSG/V2	18	77.8	38.9	66.7
PMSG/GnRH	21	90.5	47.6	47.6
Overall	78	82.1	44.9	52.6

*Estrus refers to the estrus after Synchro-Mate-B removal and gonadotropin treatment; rebred refers to breeding mark at next estrus; and pregnant refers to pregnancy diagnosed by ultrasonography at 35-40 days after LAI, and pregnant to LAI.

†No differences were observed among treatments (P>0.10) for % Estrus, % Rebred, or % Pregnant by Chi-squared test.

DISCUSSION

These data indicate that treatment with PMSG and/or GnRH does not improve the estrous response or pregnancy rate to timed insemination by LAI in seasonally estrous ewes synchronized with SMB. As stated earlier, PMSG frequently has been used in estrus synchronization programs in sheep. Typically, PMSG is used to stimulate ovarian function in ewes during seasonal anestrous, and is usually used following estrous synchronization. However, some risk occurs with the use of PMSG. Production of antibodies against PMSG may result in ovarian dysfunction, and over stimulation of follicular growth can result in production of multiple births in excess of 2 lambs. Furthermore, PMSG is not commercially available in the USA and is not approved for use in sheep. Therefore, our objective was to determine if PMSG that is commonly used in estrous stimulation/synchronization procedures during seasonal anestrous is necessary for these same procedures during the breeding season. The results from the present study have shown that PMSG had no significant effect on percent of ewes expressing synchronized estrus or on percent of ewes conceiving to LAI, suggesting that PMSG may not be necessary in these procedures.

Since LAI is conducted at a specific time after synchronized estrous (58-60 hrs), it is important that ovulation occur in synchrony among ewes so that insemination time with respect to ovulation time is constant among all ewes. Presumably, this will ensure that the oocytes (eggs) are maximally matured and ready to be fertilized, and that the semen is capacitated and ready to fertilize the oocytes after LAI. A large window in ovulation time will inherently result in lower conception rates because the oocytes may not be at their optimal stage of maturation for being fertilized. Therefore, a second objective of this study was to determine if GnRH, which induces ovulation 24 hrs after treatment, could increase the conception rates to LAI by "forcing" all oocytes to be at approximately the same stage of maturation at the time of insemination. The results from the present study have shown that GnRH had no significant effect on percent of ewes expressing synchronized estrus or on percent of ewes conceiving to LAI, suggesting that use of GnRH has no distinct advantage in this protocol.

An important point to note, however, is that 64 percent of the ewes that expressed estrus after synchronization conceived to LAI, whereas only 53 percent of the total number of ewes conceived to LAI. This indicates that ewes that did not express estrus after synchronization were less likely to conceive to LAI. Therefore, optimizing procedures to improve estrus synchronization response would result in increased conception rates at LAI.

Results from the study herein indicate that there is no advantage to using PMSG and/or GnRH in this particular timed LAI procedure. Whether these hormone serve to improve pregnancy rates in procedures that have different protocols remains to be tested. It is important to note that the data reported herein is based on approximately 20 animals per treatment group. A larger scale study would be necessary to detect small but significant effects. Future studies regarding the optimization of procedures used to synchronize estrus in ewes both during and after the breeding season will provide improved pregancy rates and overall success of these assisted reproductive techniques.

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SECTION II
MANAGEMENT SECTION

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41ST ANNUAL SHEEP DAY

HETTINGER RESEARCH EXTENSION CENTER
HETTINGER, NORTH DAKOTA

FEBRUARY 9, 2000

FLOCK CALENDAR OUTLINE

The following guidelines are neither inclusive nor intended to fit every sheep operation. Each operation is different, therefore, each "calendar of events" should be tailored to each flock's needs.

PRIOR TO BREEDING

1. Bag and mouth ewes and cull those that are not sound.

2. Replace culled ewes with top-end yearlings or ewe lambs.

3. Keep replacement ewe lambs on growing ration.

4. Evaluate sires:

   a. Be sure they are vigorous, healthy and in good breeding condition.

   b. Rams should be conditioned at least a month before the breeding season. Flush rams in poor condition.

   c. Allow at least two mature rams (preferably three) or four buck lambs per 100 ewes.

   d. Utilize production records to evaluate anticipated breeding ability.

5. Flush ewes:

   a. One pound grain/day two to five weeks before breeding (usually 17 days).

   b. If ewes are over-conditioned, the effect of flushing will be lessened.

6. Vaccinate ewes for vibriosis and enzootic abortion (EAE).

7. Identify all ewes and rams with ear tags, paint brands or tattoos.

BREEDING

1. The ovulation rate of a ewe tends to be lowered at the first part of the breeding season. Vasectomized or teaser rams run with the ewes through the first heat period tend to stimulate them and increase the ovulation rate at the second heat period.

2. Use a ram marking harness or painted brisket to monitor breeding. Soft gun grease with paint pigment mixed in works well for painting the brisket. A color sequence of orange, red and black is recommended with colors being changed every 17 days.

3. Leave rams in NO LONGER than 51 days (35 days is more desirable).

    a. An exception may be with ewe lambs. Allowing them four heat cycles or 68 days may be beneficial.

4. Remove rams from ewes after the season (don't winter rams with ewes).

PRIOR TO LAMBING — EARLY PREGNANCY (First 15 Weeks)

1. Watch general health of ewes. If possible sort off thin ewes and give them extra feed so they can catch up.

2. Feed the poor quality roughage you have on hand during this period, saving the better for lambing.

3. An exception to the above is feeding pregnant ewe lambs. They should receive good quality roughage and grain (about 20 percent of the ration) during this period.

LAST SIX WEEKS BEFORE LAMBING

1. Trim hooves and treat for internal parasites.

2. Six to four weeks before lambing feed 1/4 to 1/3 pound grain/ewe/day.

3. Shear ewes before lambing (with highly prolific ewes at least a month before is preferred). Keep feeding schedule regular and watch weather conditions immediately after shearing (cold).

4. Vaccinate ewes for enterotoxemia.

5. Control ticks and lice immediately after shearing.

6. Four weeks before lambing increase grain to ½ to 3/4 pound/ewe/day (usually done immediately after shearing).

7. Give A-D-E preparations to ewes if pastures and/or roughage are or have been poor quality.

8. Feed selenium-vitamin E or use an injectable product if white muscle is a problem. **Caution** — Don't do both.

9. Check facilities and equipment to be sure everything is ready for lambing.

10. Two weeks before lambing increase grain to 1 pound per ewe per day.

LAMBING

1. Be prepared for the first lambs 142 days after turning the rams in with the ewes, even though the average pregnancy period is 148 days.

2. Watch ewes closely. Extra effort will be repaid with more lambs at weaning time. Saving lambs involves a 24-hour surveillance. Additional help at this time is money well spent.

3. Put ewe and lambs in lambing pen (jug) after lambing (not before).

4. Grain feeding the ewes during the first three days after lambing is **not** necessary.

5. Be available to provide assistance if ewe has troubles.

6. Disinfect lamb's navel with iodine as soon after birth as possible.

7. Be sure both teats are functioning and lambs nurse as soon as possible.

8. Use additional heat sources (heat lamps, etc.) in cold weather.

9. Brand ewe and lambs with identical number on same sides. Identify lambs with ear tags, tattoos or both.

10. Turn ewe and lambs out of jug as soon as all are doing well (one to three days).

11. Bunch up ewes and lambs in small groups of four to eight ewes and then combine groups until they are a workable size unit.

12. Castrate and dock lambs as soon as they are strong and have a good start (two days to two weeks of age). Use a tetanus toxoid if tetanus has been a problem on the farm (toxoids are not immediate protection. It takes at least ten days for immunity to build).

13. Vaccinate lambs for soremouth at one to two weeks of age if it has been a problem in the flock.

14. Provide a place for orphaned lambs. Make decision on what lambs to orphan as soon after birth as possible for the best success. Few ewes can successfully nurse more than two lambs.

END OF LAMBING TO WEANING

1. Feed ewes according to number of lambs suckling. Ewes with twins and triplets should receive a higher plane of nutrition.

2. Provide creep feed for lambs (especially those born during the winter and early spring).

3. Vaccinate lambs for overeating at five weeks and seven weeks of age.

WEANING

1. Wean ewes from lambs, not lambs from the ewes. If possible, remove ewes from pen out of sight and sound of lambs. If lambs have to be moved to new quarters, leave a couple of ewes with them for a few days to lead the lambs to feed and water locations.

2. Lambs should be weaned between 50 and 60 days of age or when they weigh at least 40 pounds and are eating creep and drinking water. The advantage of early weaning is that the ewe's milk production drops off to almost nothing after eight weeks of lactation.

3. Grain should be removed from the ewe's diet at least one week prior to weaning and low quality roughage should be fed. Restriction of hay and water to the ewe following weaning lessens the chance of mastitis to occur. Poorer quality roughage should be fed to the ewes for at least 10 to 14 days following weaning.

4. Handle the ewes as little as possible for about 10 days following weaning. Tight udders bruise easily. If possible, bed the area where the ewes will rest heavily with straw to form a soft bed for the ewes to lay on.

WEANING TO PRE-BREEDING

1. If ewes go to pasture, treat for internal parasites.

2. Feed a maintenance ration to the ewes. Put ewe lambs that lambed back on a growing ration once they have quit milking.

3. Adjust ewe's conditions so they can be effectively flushed for next breeding season. Don't get ewes too fat prior to breeding.

REARING LAMBS ARTIFICIALLY (ORPHANS) — MANAGEMENT TIPS

Within 2 to 4 hours after birth, decide which lambs among those from multiple births you should remove. Look for the weaker, or smaller ones to choose for artificial rearing. It is important to make this decision early. Relatively weak lambs remaining with the ewes can experience more stress than those reared artificially. Consider the following tips:

- It is essential that newborn lambs receive colostrum milk. Cow's colostrum will work if ewe's milk is not available. Do not dilute with water or warm too quickly if colostrum is frozen.

- Lambs should be removed from sight and hearing distance of ewe.

- Provide a warm, dry, draft-free area to start lambs.

- Use a good milk replacer that is 30% fat and at least 24% protein. Each lamb will require from 15 to 20 pounds of replacer to weaning.

- Use good equipment. Self priming nipple and tube assemblies have been found to be excellent for starting lambs.

- Lambs may require some assistance the first day or two to teach them to nurse on whatever feeding device is used.

- Start on nurser quickly. Young lambs start easier.

- Self feed cold milk replacer after lambs are started. Milk replacers should be mixed with warm water for best results and then cooled down. Lambs fed cold milk grow well with less problems from scours and other digestive disturbance. Cold milk keeps better too.

- There is a Formaldehyde solution commercially available that retards bacterial growth in milk (1 cc/gallon milk).

- Hang a light over the milk replacer feeding device and dry ration feeder.

- Avoid placing young lambs with older lambs, as they may be pushed aside and not be able to obtain milk replacer. Remember that lambs nursing ewes drink 25 to 40 times per 24 hours. Best results have been obtained when lambs are fed in groups of 3 to 4 initially. After lambs are successfully trained, they can be handled in groups of 25.

- Inject lambs in the first few days with Iron Dextran, Vitamin A-D-E, and Selenium-Vitamin E. At 15 days of age, vaccinate for overeating (Colostridum perfringen type C & D).

- Provide lambs a high-quality creep feed as soon as possible. Provide ample fresh water in front of lambs at all times. Do not feed hay or oats the first three weeks of age as it encourages bloat. Caution! Do not feed leafy alfalfa until two weeks after weaning, as it may encourage bloat.

- Wean lambs abruptly at 21-30 days of age. When to wean depends upon whether lambs are eating creep feed and drinking water. Newly weaned lambs will go backwards for several days. Don't be alarmed, they will make compensating gains later on.

SHEEPBARNS AND EQUIPMENT PLANS

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NOTE: These and other plans are available through county agents or from Extension Agricultural Engineering, NDSU, Fargo, ND. The drawings show construction details and include a materials list for estimating. Due to changes in lumber sizes, lumber grades, plywood quality, and other developments in building materials, some adjustments are required for older plans. (Present charge is shown or $1.00 per sheet.)

CORRALS AND BARNS

Plan No.	Plan Title	Sheets
MW 72050	Pole Utility Buildings	$2.00
MW 72505	Slatted Floor, 40'x72', Feeder Lamb Barn	3.00
MW 72506	240 Ewe and Lambing Barn, 40'x104'	3.00
MW 72507	500 Ewe and Lamb Feeding Barn, 74'x256'	3.00
MW 72508	12' x 16' Portable Lamb Feeding Shed	2.00
MW 72509	40 Ewe and Lambing Barn, 24x32'	2.00
ND Plan	Confinement Sheep Barn & Hay Storage (at Hettinger)	1.00
Reprint #759	Practical Sheep Housing for North Dakota	No Charge
USDA 6096	Shearing Shed & Corral Arrangement	1
USDA 6236	Portable Handling Corral for Sheep (Metal Wood)	1
AE-683	Sheep Barn Layout	No Charge
AED-13	Insulation and Heat Loss	No Charge
AED-19	Slip Resistant Concrete Floors	No Charge
AED-25	Earth Tube Heat Exchange System Planning	No Charge
MWPS-3	Sheep Housing and Equipment Handbook (This 90 page booklet was revised in 1994. It includes barn and layout planning plus plans for fences and sheep equipment.)	10.00
MWPS-9	Designs for Glued Trusses	5.00

FEED HANDLING & FEEDERS

USDA 5917	Fencing, Feeding, and Creep Panels	1
Reprint #409	Chopped Hay Feeder for Sheep	No Charge
Reprint	16 ft. Collapsible Fenceline Feedbunk for Sheep	No Charge
ND 872-1-1	Stationary Roughage Self Feeder for 70 Ewes or 160 Lambs	No Charge
ND 872-1-2	Portable Roughage Self Feeder for 40 Ewes or 80 Lambs	No Charge

Plan No.	Plan Title	Sheets
MW 73110	24 ft. wide Clearspan Pole Frame Hay Shed	$ 3.00
MW 73111	36 ft. wide Clearspan Pole Frame Hay Shed	3.00
MW 73112	48 ft. wide Clearspan Pole Frame Hay Shed	3.00
MW 73113	32 ft. & 48 ft. Wide Pole Frame Hay Shed (Interior Poles)	3.00
MW 73210	Moveable Grain Storage Walls, 6' to 12' High	2.00
MW 73217	20, 45, 170, and 340 Bu. Hoppered Grain Bins	3.00
MW 73220	48 ft. Wide Pole Frame Grain Storage	2.00
MW 73250	Grain Storage Buildings, 600, 1000, 1200, 1500 or 2000 Bu.	3.00
MW 73293	Grain-Feed Handling Center, Work Tower Across Drive	4.00
MW 73294	Grain-Feed Handling Center, Work Tower Beside Drive	4.00
APA	10 Ton Hoppered Feed Bin	No Charge
APA	4 Compartment Bin for Feed Mill	No Charge
AED-15	Horizontal Bunker Silos, Concrete Tilt-up	No Charge
USDA 6090	5500 Bushel Wooden Grain Bin	2
MWPS-13	Planning Grain-Feed Handling Handbook	5.00