REPORT NO. 38

WESTERN DAKOTA SHEEP DAY

February 12, 1997

HETTINGER ARMORY

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

February 12, 1997

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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This publication will be made available in alternative formats upon request. Six hundred copies of this publication were printed at a cost of $2.10 each. Contact Hettinger Research Extension Center, 701-567-4323.

PROGRAM

9:45 AM (MST)	Sheep Equipment Display and Coffee at the Hettinger Armory
10:10 AM	Early Bird Door Prize Drawing
10:15 AM	HETTINGER & FARGO STATION REPORTS Dr. Kris Ringwall Dr. Paul Berg Mr. Roger Haugen Dr. Woodrow Poland Mr. Dan Nudell Mr. Timothy Faller
12:00 NOON	LUNCH: AMERICAN LAMB DINNER
1:00 PM	WELCOME Dr. Jerry Dodd Chairman, Department of Animal and Range Sciences North Dakota State University
1:15 PM	"ECONOMICS OF HAYING/GRAZING vs CROPPING CAP LANDS" Paul Nyren, Director Central Grasslands Research Center Streeter, North Dakota
1:40 PM	"HIGH LEAN LAMBS via THE CALLIPYGE GENE and SELECTION FOR IMPORTANT MATERNAL TRAITS" Dr. Gary Snowder, Geneticist U.S. Sheep Experiment Station Dubois, Idaho
2:35 PM	"SHEEP PRODUCER'S FORUM" Roger Haugen, NDSU and Jeff Held, SDSU Bill Clarkson, Burdell Johnson Don McKinstry, Gerhardt Reichenbach A.J. Lindskov, Don Myaer
3:15 PM	"CLOSING REMARKS" Wyman Sheetz, Vice President North Dakota Lamb & Wool Producers Assoc. Hensler, North Dakota

*There will be a spouse program in the afternoon beginning at 1:15 PM. Presentations at this program will focus on "COOKING WITH LAMB" and "WHO GETS GRANDMA'S CANDY DISH?".

SHEEP DAY DIGEST

by
Timothy C. Faller, Director
Hettinger Research Extension Center
North Dakota State University

SECTION I
REPORTS OF RESEARCH IN PROGRESS
AT THE
HETTINGER RESEARCH AND EXTENSION CENTER
AND MAIN STATION

DR. PAUL BERG
DEPT. OF ANIMAL & RANGE SCIENCES
NORTH DAKOTA STATE UNIVERSITY

TIMOTHY C. FALLER
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MR. ROGER HAUGEN
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MR. DAN NUDELL
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DR. WOODROW POLAND
LIVESTOCK SPECIALIST
DICKINSON RESEARCH EXTENSION CENTER

DR. KRIS RINGWALL
EXTENSION LIVESTOCK SPECIALIST
NORTH DAKOTA STATE UNIVERSITY

AT THE
38TH ANNUAL SHEEP DAY

HETTINGER RESEARCH EXTENSION CENTER
HETTINGER, NORTH DAKOTA

FEBRUARY 12, 1997

Whole *Paul* oat as a feedstuff for sheep.[1]

W. W. Poland[a] and T.C. Faller[b]

Introduction

Alternative crops are playing a greater role in North Dakota field crop production. Common oats is lower in energy and more bulky than other feed grains, since it threshes with the hull intact. Oat groat (oat grain minus the hull) is comparable to corn in feeding value, but is usually quite expensive. Oat hulls are less palatable and lower in nutritive value than oat groats. Because of these characteristics, conventional oat is not widely used in the feeding of livestock. Hulless varieties of oat are accessible, but grain availability has been limited. Because of a reduced hull concentration, hulless oat may have a feeding value similar to oat groats (e.g. higher digestibility, higher protein, lower fiber). Several naked oat varieties are being developed in the U.S. and Canada. *Paul* oat is a hulless oat variety that was recently developed in North Dakota.

Traditionally, hulless varieties of oat are not fed to livestock in North Dakota. As the acreage for this crop expands, producers are looking for alternative markets for their grain. Chemical composition suggests that hulless oat has potential for use as livestock feed (Table 1). Several cattle feeding studies have been conducted in North Dakota to evaluate the feeding potential of *Paul* oat. These studies have indicated that *Paul* oat is a suitable substitute for barley and soybean oil meal (SBOM), when replacement is on an equivalent protein basis. Improved feed efficiencies associated with diets containing processed (e.g. coarsely ground, rolled) *Paul* oat suggest the net energy concentrations for this particular feed grain exceeds those of barley.

A lamb feeding study was designed to evaluate the feeding potential of *Paul* oat in finishing lamb diets. The study involved substituting all or a portion of the barley and SBOM in a control diet with graded levels of whole *Paul* oat. This type of information is vital for future use of this test grain in diet formulations.

Materials and Methods

Two hundred forty lambs were used to investigate the feeding potential of whole *Paul* oat as a feedstuff in finishing diets. Lambs (78.3 lbs average initial BW) were allotted by weight and sex into 8 finishing pens on January 16, 1996. Four dietary treatments were then assigned to the pens (2 pens/treatment). A 84% concentrate, self-fed control diet (0%PO) was formulated to contain barley, SBOM, ground alfalfa hay and straw (Table 2). Three other diets were constructed where *Paul* oat replaced one-third (33%PO), two-thirds (66%PO) or all (100%PO) of the barley and SBOM in the control diet. The nutritional composition of the diets are also presented in table 1. Vitamins and minerals (@ 4% of diet) were provided to meet or exceed NRC (1985) requirements. Lambs were fed for 79 days. Lamb weights were recorded initially and at the conclusion of the study.

1 a Area Livestock specialist, Dickinson Research /Extension Center
b Director, Hettinger Research /Extension Center

A selected group of wether and ewe lambs were slaughtered at a commercial packing plant, however, carcass data is not available at this time.

Data were analyzed using pen as the experimental unit. Initial weight of lambs that died during the course of the experiment were deleted from their respective pen data. Death loss is reported as the number of lambs per treatment that died expressed as a percentage of the total number of lambs in that treatment.

Results

Feedlot performance is summarized in table 3. Including whole *Paul* oat in a high concentrate diet reduced final weights ($P < .002$), total ($P < .001$) and average daily ($P < .001$) gain and average daily feed intake ($P < .001$). Feed intake and gain depressions were inversely related to level of *Paul* oat in the diet (i.e. as *Paul* oat in the diet increased, intake and gain decreased). In terms of feed efficiency, the depressions in intake and gain were offsetting, such that, feed efficiencies were not affected by the inclusion of *Paul* oat in to high concentrate finishing diets.

Conclusion

The results of this study are similar to those of Johnson et al. (1995), where whole *Paul* oat was fed to growing calves. In that study, *Paul* oat and barley had similar feed values. The depression in intake seen in the lamb diets containing *Paul* oat is consistent with several reports where processed (e.g. coarsely ground, rolled) *Paul* oat was feed to beef calves (Poland and Landblom, 1996; J. Caton and V. Anderson, unpublished data). One difference is that feed efficiencies were improved even though intake was reduced (Poland and Landblom, 1996). This allowed for similar average daily gains on less feed when *Paul* oat was fed to growing beef calves.

References

Johnson, J., D. Dhuyvetter, B. Kreft, and K. Ringwall. 1995. A comparison of naked oats to barley when fed in a grower diet to beef calves. North Dakota cow/calf conference and beef cattle and range research report. December 1 and 2, Bismarck.

NRC. 1985. Nutrient requirements of sheep. National Research Council.

Poland, C. and D. Landblom. 1996. Feeding value of field pea and hulless oat in growing calf diets. Proceedings of the ND Cow Calf Conference. Bismarck, December 6-7.

Table 1. Nutritional composition[a] of field pea and hulless oat.

Item	*Paul* oat	Corn	Barley	Oat	SBOM
Crude protein	17.3	10.1	13.5	13.3	49.9
Ether extract	9.4	4.2	2.1	5.4	1.5
Neutral detergent fiber	13.6	-	-	31.0	-
Acid detergent fiber	4.2	5	7	16	-

[a] Composition reported in NRC (1985).

Table 2. Diet composition and nutrient analysis of finishing lamb diets containing *Paul* oat.

	Treatment			
Item	0%PO	33%PO	66%PO	100%PO
Ingredients[a]:				
Barley	76.0	50.5	25.5	0
SBOM[b]	8.0	5.5	2.5	0
Paul Oat	0	28.0	56.0	84.0
Alfalfa hay	5.0	5.0	5.0	5.0
Straw	7.0	7.0	7.0	7.0
Supplement[c]	4.0	4.0	4.0	4.0
Nutrients[d]:				
Dry matter	90.4	90.7	90.9	91.0
Crude Protein	16.6	17.1	17.3	18.1
Fat	2.16	3.60	5.30	7.31
NDF	21.4	22.1	21.8	19.4
ADF	9.54	9.13	8.27	8.65
Ca, %	1.43	1.34	1.50	1.55
P, %	.36	.37	.38	.36

[a] Dietary ingredient composition is expressed on a dry matter basis.
[b] Soybean oil meal.
[c] All diets formulated to contain 3% ground limestone, 0.5% trace mineral salt, 0.5% ammonium chloride and 0.05% vitamins A, D and E supplement.
[d] Formulated compositional values are expressed on a dry matter basis.

Table 3. Effects of feeding *Paul* oat on feedlot performance of finishing lambs.

Item	Treatment				
	0%PO	33%PO	66%PO	100%PO	SE
Initial weight, lbs	78.6	78.8	78.3	77.5	.56
Final weight[a], lbs	128.7	126.1	121.1	115.9	1.28
Total gain[a], lbs	50.1	47.4	42.8	38.5	1.11
Death loss, %	8.3	6.7	6.7	5.0	.
Feed intake[a], lbs	4.31	3.74	3.39	3.23	.150
Daily gain[a], lbs	.63	.60	.54	.49	.014
Efficiency:					
Gain/feed	.147	.160	.161	.151	.0083
Feed/gain	6.80	6.24	6.28	6.64	.326

[a] Linear effect of *Paul* oat ($P < .006$).

Lean Lamb Production
1997 Update

P.T. Berg, T.C. Faller, W.R. Limesand, N.M. Maddux, B.L. Moore

Introduction

Since 1993, NDSU has been collecting identification factors that will aid sheep producers in producing lean and rapidly growing lambs. These factors are found in two separate objectives that are based on lambs sets with known sires in the Columbia, Hampshire and Suffolk breeds. Analysis is done prior and during slaughter at the NDSU Meats Laboratory. Preliminary data analysis is still in progress for both the objectives. The ultimate goal is to use both these objective conclusions to establish a standard, effective EPD equation that can easily be applied by any sheep producer.

Part of this project is an evaluation of an electronic instrument which has the potential of predicting fat free mass in the live animal and its carcass. This instrument is a Bioelectric Impedance Analyzer. In theory, lean tissue conducts an electrical current differently than does fat. The BIA machine measures the amount of low energy current which is absorbed and dispersed in the body and a mathematical formula can then be developed which will predict fat free mass. This instrument has been used in carcass analysis in the first objective and both live and carcass analysis in objective two.

Objective 1 searches for actual formulas to predict lean tissue composition using lamb slaughter cutout data. All carcasses were fabricated into wholesale cuts, denuded of subcutaneous fat so that the muscle is exposed on 85% of the surface. The measurements and weights recorded during breakdown could be used as a predictor of Trimmed Retail Product (TRP). Based on this analysis, the most accurate TRP predictor should be that which balances accuracy and efficiency. The best TRP predictor should be compatible and easily incorporated into a processing line.

421 lambs have been processed as of January first. Individual carcass measurements were taken and evaluated as TRP predictors of both pounds and percent of carcass weight. Certainly, actual wholesale cut weights are valuable as TRP predictors but are not efficient in predicting % TRP. Also, carcasses that are cut out and peeled of fat are limited due to time and space restraints. Therefore, the establishment of two formulas using BIA and one utilizing only anatomical data were developed. These formulas prove to be very accurate and do not depreciate the value of the carcasses. One BIA prediction formula is designed for robotic use and is not presented here. The BIA formula utilized in this data set uses the same anatomical positions of the electrode placement as done on the live animal. This formula having an R squared of .91 is as follows:

$$\text{BIA Lean C} = 6.7178 + (.4818 * \text{cold carc wt}) - (.0314 * Rs) - (.0481 * Xc) + (.254 * Ln) + (.0223 * \text{Temp})$$

The high correlation between actual cutout and anatomically predicted retail product has an R squared of .94. This suggests that predictions of TRP based on anatomical measures are satisfactory. Table 1 and 2 show averages and summaries of various measurements for live, carcass and cutout data. trimmed retail product may be predicted for carcass data using the following formula:

TRP # = 4.8 + (0.58* cold carc wt) + (1.39* ribeye area) - (7.36* adj fat) - (5.87* body wall thick)

Table 1. Slaughter Cutout Data

Trait	Average	Trait	Average
Live Wt	129.25	Conformational Score	10.79
Cold Carc Wt	69.11	Lean Color Score	3.20
Ribeye Area	2.37	Trim Retail Product	40.90# 61.55% Cold Carc Wt
Adj Fat	0.17'	BIA Pred Lean Avg	41.73# 61.92% Cold Carc Wt
Body Wall Thickness	0.76"	Anat Pred TRP	41.45# 61.78% Cold Carc Wt
Kidney Fat	1.90 lbs	Vol. (L*/(Rs + Xc))TRP	41.78# 61.99% Cold Carc Wt
USDA Yield Grade	2.28	Retail Product as % Live Wt	31.95 %
Marbling	3.95	Sum Value IMPS	$117.92
Streaking	3.90	Sum Value TRP	$149.65
Leg Score	10.94	Marbling Streaking Score =	Traces = 200
			Slight = 300
			Small = 400

* Dependent Variable

Table 2. Wholesale Cutout Data

Cut	# Untrim	% of Cut WT	Trim Cut Wt	Trim WT as % of Untrim
Shoulder	12.92	21.1	11.37	89.11
Rack	5.86	8.58	4.74	86.93
Loin	5.92	9.65	4.81	82.69
Leg	19.95	32.46	18.17	87.93
Breast, Flank	15.48	24.78	----	----

Objective 2 addresses the genetic and environmental aspect of lean tissue accretion. A full data set of 182 lambs with known sires have been processed and analyzed during the 1996 year. The lambs were evaluated by BIA immediately prior to slaughter . After a 24 hour chill, the carcasses were also evaluated by BIA using anatomical references for electrode placement similar to those used on the live animal. Few numbers of lambs within each sire group has limited the evaluation to the Columbia breed at this time. Sire groups containing five or more observations are listed in Table 3. The data shows that there is a tremendous difference within the breed sires. The total retail product between the high and low sire is $31.99. The retail product that is used for calculating the TRP value is as follows:

$ = (trim shoulder wt * $2.30) + (trim rack* $4.32) + (trim loin* $3.49) + (breast, flank, etc* $0.85* 0.5)

$ prices are from retail stores in the Fargo-Moorhead area.
Leg price is "boneless", wt is "bone in", hence the multiplier of 0.9 to get boneless wt.
Breast, shank, plate and flank yield approximately 0.5 of the wt as boneless stew/ground meat.

Table 3. Columbia Sire Average Summary

Sire	Liv Wt	Carc Wt	Eye	Fat	BodyWall Thickness	Pred #Ln	Pred %Ln	Ana #Ln	Ana %Ln	Pred #Ln	TRP
1	146.1	78.1	2.4	.2	0.8	46.7	60.5	46.4	60.7	42.2	166.2
2	124.2	65.8	2.3	.15	0.8	40.2	62.1	40.5	62.8	40.6	145.5
3	136.6	72.0	2.2	.2	0.8	44.0	62.4	42.8	60.6	43.4	155.7
4	123.0	60.0	2.3	.12	0.8	36.0	62.1	37.4	64.6	40.0	134.3
5	125.2	60.8	2.1	.18	0.8	38.0	64.6	37.7	63.5	40.3	135.5
6	128.8	67.5	2.1	.30	0.8	39.7	60.0	39.2	59.6	NA	144.9
7	142.7	71.7	2.6	.18	0.7	43.4	62.5	43.5	62.8	NA	160.2
8	126.9	69.0	2.3	.19	0.8	40.9	61.5	40.5	60.8	NA	146.0
9	132.3	66.7	2.1	.16	0.8	41.6	63.9	42.2	64.9	43.0	152.0
10	125.0	64.6	2.2	.11	0.7	37.9	60.9	41.2	66.1	40.9	148.4
11	126.2	67.2	2.2	.2	0.7	40.7	62.0	40.5	61.6	NA	145.2
12	126.0	67.2	2.1	.2	0.7	40.6	61.8	39.9	61.0	NA	140.2
13	126.2	67.2	2.2	.2	0.7	40.7	62.0	40.5	61.6	NA	145.2

Regression was run on this data set to develop a formula that could predict pounds of lean muscle mass on the live animal. With N = 182, the R-squared using this formula was .80. The R squared value represents the proportion of the variation in the dependent variable which is explained by the independent variable(s). The formula is as follows:

_-.2634 + (.3190* Liv Wt) + (.0504* Liv Rs) + (.1542* Liv Xc) - (.0169* Liv Ln)

Prospective

The Columbia selection portion of the Lean Lamb study is in its third year. Assignment of ewes to treatment groups (high lean (HL), low lean (LL), and control (CT) was done in 1994. Ram lamb selection based on BIA was done at that time. Replacement ewe and ram selection from the 1996 lamb crop was based on BIA trimmed retail product index and Columbia breed standards. All lambs were weighed and subjected to BIA analysis in May and the TRP index based on those readings were used to rank the lambs. Only Columbia type score 1 and 2 were considered for replacement. The top indexing lambs from the HL and the low indexing lambs from the LL were selected as replacements. The control group received replacements by random assignment. Lambs not assigned to a group were all processed through the NDSU meats laboratory where carcass evaluation was done. The same process will occur to the 1997 group of lambs this May.

Statistical analysis of the last formula in breed and sire comparisons is in effect at the present time. Verification of the accuracy of the Lean pounds prediction formula and data summary is in progress. The ultimate outcome is to produce an accurate formula which can be easily incorporated as an EPD value into the sheep industry. Efforts on value based marketing are accelerating and our data clearly shows the benefit of sire evaluations as a tool to increase efficiency through genetic improvement in lean growth.

Final Copy

A Five-Year (1992-1996) North Dakota Conservation Reserve Program (CRP) Grazing and Haying Study

By

William Barker, Paul Nyren, Anne Nyren, Kevin Sedivec, Charles Lura, Bob Patton, Brian Kreft, Tim Faller, Don Stecher, Jim Nelson and Dennis Whitted

This research project was supported by funds and grants from the following:

N.D. Experiment Station
Stutsman County Soil Conservation District
Ducks Unlimited
Environmental Protection Agency
U.S. Fish and Wildlife Service

Introduction

In 1991, due to efforts of Mr. Arnold Kruse, U.S. Fish and Wildlife Service (USFWS) and Mr. Jeff Printz, Soil Conservation Service (SCS), now known as Natural Resources Conservation Service (NRCS), the Agricultural Stabilization and Conservation Service (ASCS) granted permission to conduct a five-year haying and grazing study on four Conservation Reserve Program (CRP) acreages in North Dakota. Many land managers would like to see many of the highly erodible acres that have been included in CRP remain in grass.

The CRP was initiated to reduce soil erosion by 639 million tons per year, increase herbaceous cover by 7% and provide financial support for landowners. While the primary objective is the reduction of soil erosion, other benefits, include the reduction of sediment and other pollutants in wetlands, streams and rivers, protection of fisheries and water treatment systems, conservation of soil productivity, provide wildlife habitat and reduction of surplus commodities. A reduction of nutrient and sediment loads in wetland basins can improve ground water quality.

Experts state that CRP may prove to be the most important soil conservation program in the history of the United States. The latest estimates suggest that when fully implemented the CRP will generate $10 billion in natural resource benefits. The largest portion of these benefits is expected to come from improved wildlife habitat and surface water quality. Current estimates indicate that 26% of landowners participating in CRP contracts in North Dakota intend to use their CRP land for grazing purposes after their contracts expire while another 25% are undecided. These landowners will be needing information concerning grazing or haying this land upon expiration of their contracts.

In addition to landowners, policy makers will also need information about what can be expected from grazing and haying CRP acres. The Environmental Protection Agency (EPA) and many environmental groups view CRP as a way to retire land that is degrading water quality and to satisfy the non-point source pollution requirements of the Water Quality Act. These groups are mainly concerned with pollution and erosion control issues and have little concern for the economic return to the landowner. Data collected in this study will give a better understanding of the economic returns that can be expected from these CRP lands and the environmental impact of grazing and haying on these lands.

The objectives of this study were to determine:

1. The floristic composition structure of North Dakota CRP lands and to note changes in floristic composition and structure due to grazing and haying over 5 years.
2. The production and utilization of CRP land vegetation under seasonlong and twice-over grazing.
3. The production and quality of hay from CRP lands.
4. The success of game and non-game species on CRP lands.
5. The erosion from CRP lands that have been variously grazed and hayed and to compare this with similar cropland.
6. The economic returns from grazing and haying CRP lands.

Objective 1 and 2 of this study are discussed in this paper. Objectives 3 and 4 are discussed in the next paper by Sedivec et al. in this publication entitled, **Livestock and Wildlife of CRP Lands/A Guide**. Objective 5 is discussed in a paper by Nyren et al. in this publication entitled, **Grazing and Haying Effects on Runoff and Erosion From a Former Conservation Reserve**

Program Site. Objective 6 is discussed in another paper by Nyren et al. in this publication entitled, **An Economic Analysis of Grazing, Haying and Cropping Systems On Corpland In Southcentral North Dakota.**

Methods and Materials

Four study sites located in Stutsman, Ward, Adams and Bowman Counties, North Dakota are included in this project. Figure 1 shows the locations of these in North Dakota. In Stutsman, Ward and Bowman, counties there are three pastures in a twice-over rotation grazing system and one pasture which is a seasonlong grazing treatment. Figures 2 through 5 show the Stutsman, Ward, Adams and Bowman pastures. Each of these sites has an area that will be hayed each year. In Adams County there are four pastures. One of these pastures will be hayed and three will be grazed using a twice-over grazing system. The pasture to be hayed will be rotated each year. Cow-calf pairs were used to graze the Stutsman and Ward Counties sites. Yearling heifers were used to graze the Bowman County site. Yearling heifers and yearling ewes were used to graze the Adams County site.

The forage production and utilization was determined using exclosure cages and a paired plot clipping technique on overflow and silty sites in Bowman, Ward and Stutsman Counties and on silty and clayey sites in Adams County in each pasture of the grazing treatments.

Floristic composition and structure data were determined using points analysis and frequency quadrats. Frequency, basal cover and density were determined by these methods. The data from the 50x50 cm quadrats were taken on transects in each pasture on silty and overflow sites in Stutsman, Ward and Bowman Counties and on silty and clayey sites in Adams County.

The livestock were weighed at the start of grazing and at the end of grazing and the average daily gain and the gain per acres were calculated for the grazing treatments.

In 1992, potential runoff and erosion was evaluated in the Stutsman County study site using an overhead soil rainfall simulator, which applies water at the rate of 2 inches per hour. Following the grazing season, the device was set up on a silty site on the seasonlong pasture on one of the rotation pastures on the hayed area and on the ungrazed exclosure. Three runs were made at each site. The first run took place with existing soil moisture conditions and lasted 1 hour. The second run was made one-half hour later under saturated soil moisture conditions and lasted one-half hour. The third run took place one-half hour after the second run and lasted one-half hour. Runoff samples were collected and analyzed to determine the amount of sediment. The results of this work will be presented in a separate paper. The economic considerations of grazing and haying CRP grasslands will be presented in a separate paper by Paul Nyren.

Results

Table 1 shows the forage production on the hayed areas and on the grazing treatments at the four study sites for five years. The forage production is firstly related to the original stand obtained when the CRP was planted. When left idle litter readily builds up due to the relatively slow decomposition rate in North Dakota. Often the litter weight can equal several years production on CRP grasslands. A lower production of forage often accompanies this build up. Grazing and haying often improves the production of the CRP grasslands.

The seasonal variation in grassland production should be mentioned here. In years with

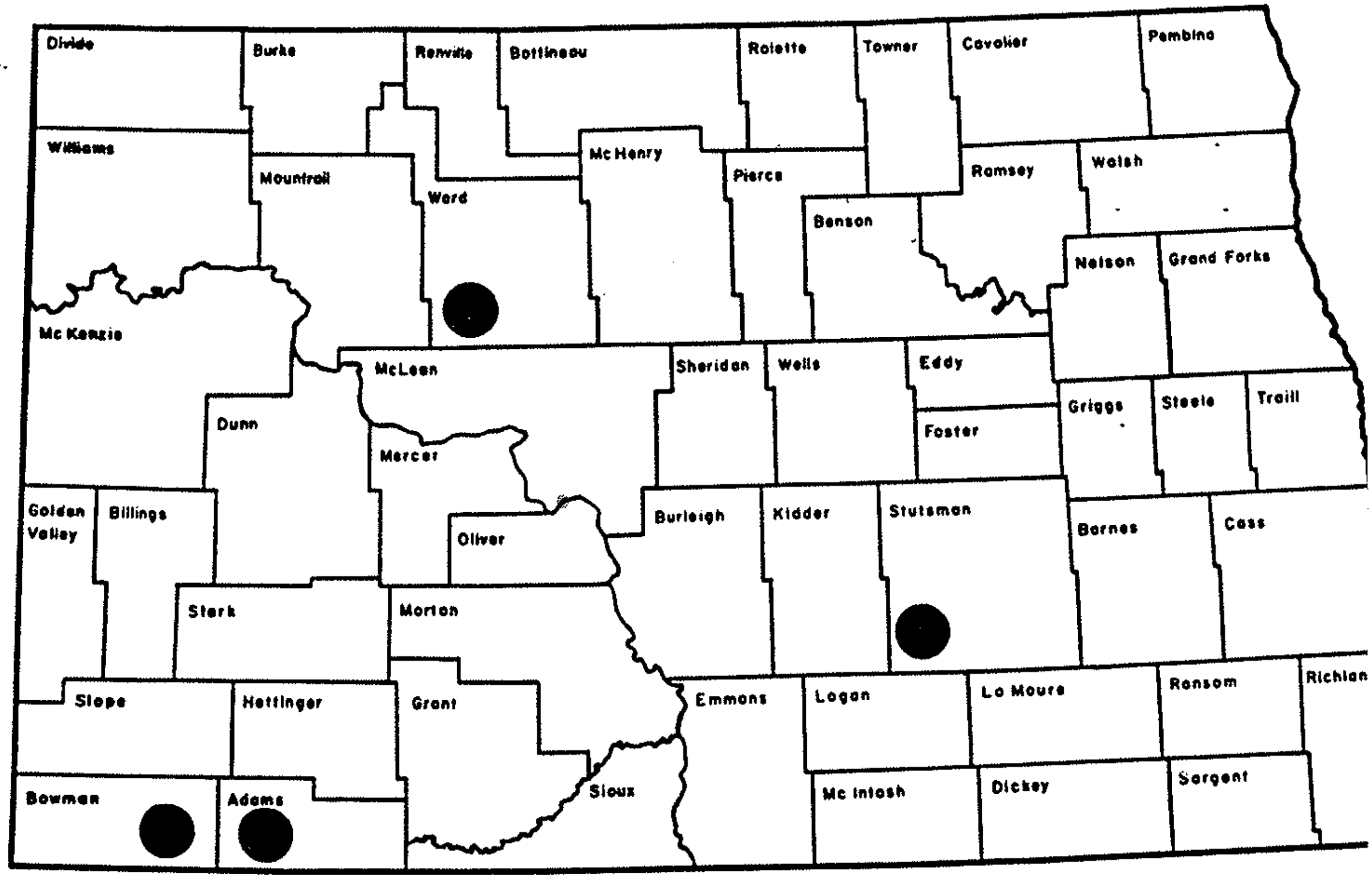
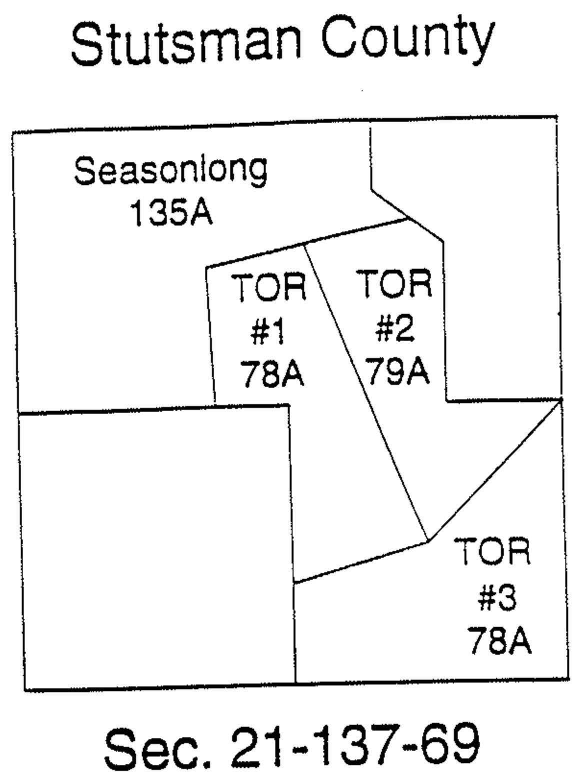


Figure 1. Map showing the locations of the Conservation Reserve Program grazing and haying study sites.

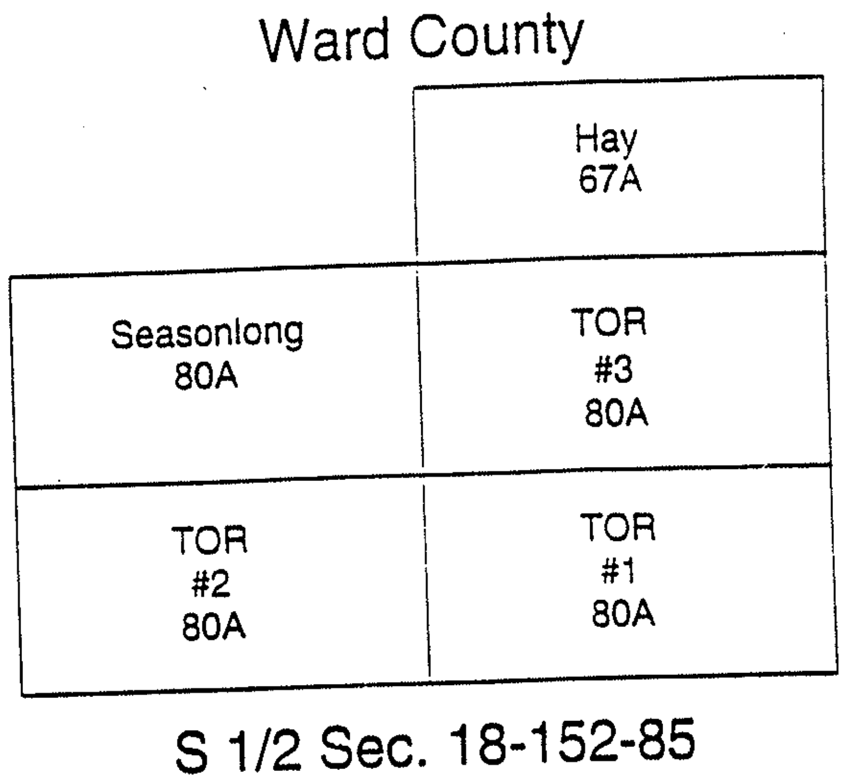


Stutsman County

Year	Pasture Rotational Sequence	Period of Grazing	Days
1992	1, 2, 3, 1, 2, and 3	5-15-92 to 9-18 92	126
1993	2, 3, 1, 2, 3, and 1	5-14-93 to 9-17-93	126
1994	3, 1, 2, 3, 1, and 2	5-19-94 to 9-23-94	127
1995	1, 2, 3, 1, 2, and 3	5-17-95 to 9-14-95	120
1996	2, 3, 1, 2, 3, and 1	5-17-96 to 9-23-96	129

(21 day rotations)

Figure 2. Diagram of grazing treatments showing the pastures, grazing sequences, peroids of grazing, and number of days grazing.

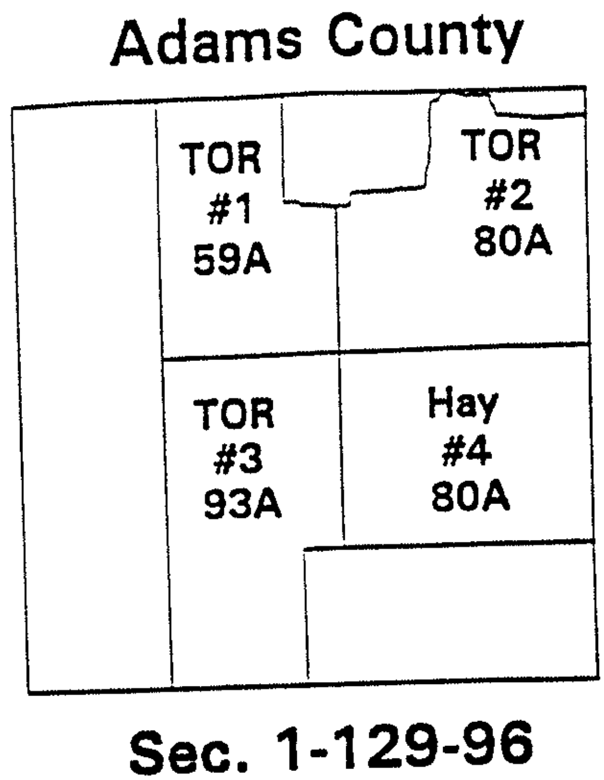


Ward County

Year	**Pasture Rotational Sequence**	**Peroid of Grazing**	**Days**
1992	1, 2, 3	6-2-92 to 8-20-92	79
1993	2, 3, 3, 2, 3, and 1	5-14-93 to 1-17-93	126
1994	3, 1, 2, 3, 1, and 2	5-19-94 to 9-23-94	127
1995	1, 2, 3, 1, 2, and 3	5-17-95 to 9-14-95	120
1996	2, 3, 1, and 2	5-24-96 to 8-7-96	75

(21 day rotations)

Figure 3. Diagram of grazing treatments showing the pastures, grazing sequences, periods of grazing, and number of days grazing.



Adams County

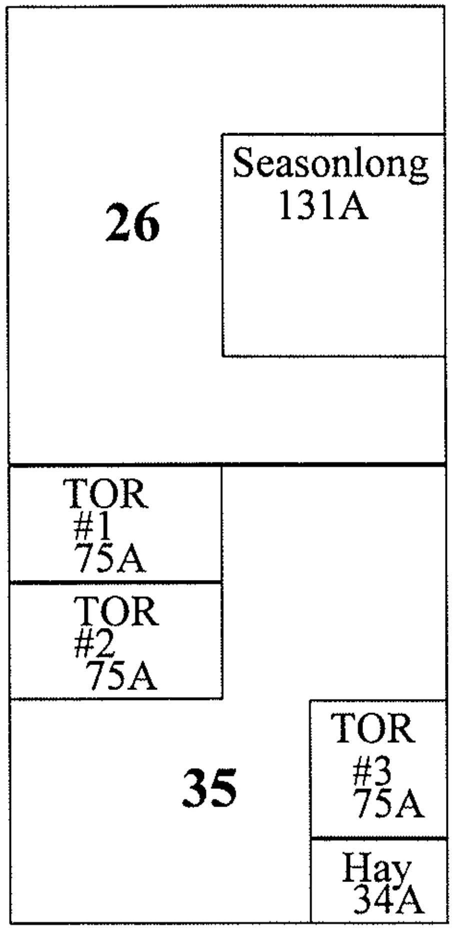
Year	Pasture Rotational Sequence	Peroid of Grazing	Days
1992	1, 2, 3, 1, 2, and 3	5-18-92 to 9-18-92	123
1993	2, 3, 4, 2, 3, and 4	5-18-93 to 9-21-93	126
1994	3, 4, 1, 3, 4, and 1	5-23-94 to 8-31-94	100
1995	4, 1, 2, 4, 1, and 2	5-24-95 to 9-27-95	126
1996	1, 2, 3, 1, 2, and 3	5-23-96 to 9-23-96	123

(21 day rotations)

(Each year a pasture was hayed instead of being grazed)

Figure 4. Diagram of grazing treatments showing the pastures, grazing sequences, peroids of grazing, and number of days grazing.

Bowman County



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Bowman County

Year	**Pasture Rotational Sequence**	**Peroid of Grazing**	**Days**
1992	1, 2, 3, 1, 2, and 3	5-14-92 to 9-18-92	127
1993	2, 3, 1. 2, 3, and 1	5-18-93 to 9-21-93	126
1994	3, 1, 2, 3, 1, and 2	5-19-94 to 9-29-94	133
1995	1, 2, 3, 1, 2, and 3	5-25-95 to 9-25-95	123
1996	1, 3, 2, 1, 3, and 2	5-28-96 to 9-25-96	120

(21 day rotations)

Figure 5. Diagram of grazing treatments showing the pastures, grazing sequences, periods of grazing, and number of days grazing.

Table 1. Total forage production and percent utilization on 4 CRP study locations 1992-1996.

		1992		1993		1994		1995		1996		5-Yr Average	
Location	Treatment	Lb/ac	% Util[1]	Lb/ac	% Util	Lb/ac	% Util	Lb/ac	% Util	Lb/ac	% Util	Lb/ac	% Util
Adams	Hayed	2660		1500		1440		3620		3855		2615	
	Non-Grazed	N/A		N/A		1886		4810		3728		3475[2]	
	Twice-over rotation	3488	58	4009	53	2236	71	6146	56	4501	61	4076	60
Bowman	Hayed	5740		2860		1600		4880		3443		3705	
	Non-Grazed	N/A		3527		3008		4065		3453		3513[3]	
	Season-long	3600	38	6717	27	7607	27	8113	37	6959	36	6599	33
	Twice-over rotation	3991	53	4140	50	4292	51	6600	51	7396	46	5284	50
Stutsman	Hayed	4920		3480		3240		4480		3409		3906	
	Non-grazed	2076		1948		2658		4778		3472		2986	
	Season-long	2902	67	5006	39	5601	46	6434	37	4112	47	4811	47
	Twice-over rotation	2937	59	5685	56	4996	64	7518	52	4132	70	5054	60
Ward	Hayed	1620		1800		2100		N/A		985		1626[3]	
	Non-grazed	1380		2944		2880		2738		1420		2272	
	Season-long	2971	41	7907	51	7391	47	5672	46	2827	54	5354	48
	Twice-over rotation	2408	52	5413	63	4861	66	4642	73	2403	67	3945	64

[1]Util= Percent utilization
[2]3-year average
[3]4-year average

Table 2. Five-year average livestock production on four CRP locations in North Dakota in 1992-1996.

Grazing System	No. of acres	Average Number and Type of Animals	Average Grazing Season Length (Days)	Cows 5-Year Average		Calves 5-Year Average	
				ADG (lb)	Gain/A (lb)	ADG (lb)	Gain/A (lb)
Bowman							
SL	131	See Note[1]	126	1.09[1]	24.61[1]	2.46[2]	46.95[2]
TOR	225	See Note[1]	126	1.17[1]	30.90[1]	2.50[2]	58.02[2]
Stutsman							
SL	135	32 cow-calf pr	126	1.65	49.06	2.92	86.23
TOR	235	55 cow-calf pr	126	1.52	44.71	2.85	83.75
Ward							
SL	70	16 cow-calf pr	105	1.17	28.22	2.94	70.96
TOR	208	49 cow-calf pr	105	0.88	23.14	2.78	67.09
Adams						Sheep	
TOR	232	60 yearling heif.	120	1.14	35.74		
		121 yearling ewes				0.30	18.62

[1]Bowman County used yearlings heifers in 1992, cow-calf pairs in 1993, 1995, 1996 and bred heifers in 1994.
[2]3-year average

Table 3. Changes in species composition ($p \leq 0.05$) on Stutsman Co. CRP sites since 1992.

	Silty Sites	Overflow Sites
Species seeded in 1987	alfalfa intermediate wheatgrass smooth brome tall wheatgrass yellow sweetclover	alfalfa intermediate wheatgrass smooth brome tall wheatgrass yellow sweetclover
Decreased since 1992	annual foxtails Japanese brome slender wheatgrass tall wheatgrass total plant basal cover	annual foxtails Japanese brome prickly lettuce tall wheatgrass
Increased since 1992	smooth brome	bare ground common dandelion smooth brome yellow wood sorrel
Fluctuated	charlock mustard common dandelion field sowthistle horse-weed intermediate wheatgrass and quackgrass narrow-leaved goosefoot Russian thistle wild buckwheat yellow sweetclover	charlock mustard field sowthistle intermediate wheatgrass and quackgrass narrow-leaved goosefoot Russian thistle Total plant basal cover wild buckwheat yellow sweetclover
Increased on non-grazed	blue lettuce smooth brome	–
Increased on hayed	bare ground litter wild buckwheat	alfalfa western rock jasmine
Increased on seasonlong	common dandelion western ragweed	Flodman's thistle horse-weed Kentucky bluegrass yellow sweetclover yellow wood sorrel
Increased on twice-over rotation	common dandelion litter	alfalfa kochia narrow-leaved goosefoot smooth brome
Decreased on non-grazed	alfalfa	–
Decreased on hayed	alfalfa intermediate wheatgrass and quackgrass	Intermediate wheatgrass and quackgrass tall wheatgrass
Decreased on seasonlong	litter skeletonweed	charlock mustard
Decreased on twice-over rotation	alfalfa bare ground	horse-weed

Table 4. Changes in species composition ($p \leq 0.05$) on Ward Co. CRP sites since 1992.

	Silty Sites	Overflow Sites
Species seeded in 1987	alfalfa slender wheatgrass western wheatgrass yellow sweetclover	alfalfa slender wheatgrass western wheatgrass yellow sweetclover
Decreased since 1992	alfalfa field milk-vetch intermediate wheatgrass	alfalfa blue lettuce Flodman's thistle intermediate wheatgrass kochia peppergrass wild buckwheat
Increased since 1992	Field sowthistle	Canada thistle common dandelion lamb's quarters panicled aster
Fluctuated	downy brome flixweed Russian thistle wild buckwheat wildoats yellow foxtail	charlock mustard downy brome flixweed intermediate wheatgrass & quackgrass wildoats yellow foxtail
Increased on non-grazed	downy brome field sowthistle lamb's quarters	–
Increased on hayed	field sowthistle quackgrass Russian thistle yellow foxtail	Canada thistle goat's beard smooth brome
Increased on seasonlong	field sowthistle flixweed lamb's quarters quackgrass Russian thistle wild buckwheat yellow foxtail	alfalfa common dandelion flixweed intermediate wheatgrass & quackgrass wildoats yellow sweetclover
Increased on twice-over rotation	quackgrass wild buckwheat	Canada thistle common dandelion curly dock downy brome flixweed Flodman's thistle foxtail barley goat's beard smooth brome wild buckwheat wildoats
Decreased on non-grazed	western wheatgrass yellow foxtail	–
Decreased on hayed	downy brome	yellow sweetclover
Decreased on seasonlong	western wheatgrass	–
Decreased on twice-over rotation	Russian thistle	–

Table 5. Changes in species composition ($p \leq 0.05$) on Clay sites in Adams Co. CRP since 1992.	
Species seeded in 1987	alfalfa intermediate wheatgrass western wheatgrass
Decreased since 1992	common dandelion downy brome kochia rough pigweed Russian thistle wild buckwheat yellow foxtail
Increased since 1992	Japanese brome tumbling mustard
Fluctuated	alfalfa annual bromes bladderpod blue lettuce field sowthistle intermediate wheatgrass western wheatgrass yellow sweetclover
Increased on non-grazed	field pennycress field sowthistle
Increased on twice-over rotation	wild buckwheat yellow sweetclover
Decreased on non-grazed	wild buckwheat yellow sweetclover

Table 6. Changes in species composition ($p \leq 0.05$) on Bowman Co. CRP sites since 1992.

	Silty Sites	Overflow Sites
Species seeded in 1988	crested wheatgrass intermediate wheatgrass alfalfa	crested wheatgrass intermediate wheatgrass alfalfa
Decreased since 1992	common dandelion intermediate wheatgrass yellow foxtail	common dandelion
Increased since 1992	crested wheatgrass horse-weed Japanese brome peppergrass	crested wheatgrass horse-weed peppergrass western rock jasmine western wheatgrass
Fluctuated	annual bromes Russian thistle smooth brome western wheatgrass yellow sweetclover	American vetch annual bromes intermediate wheatgrass yellow foxtail yellow sweetclover
Increased on non-grazed	Japanese brome	–
Increased on hayed	crested wheatgrass thyme-leaved spurge western wheatgrass wild buckwheat yellow foxtail yellow sweetclover	alfalfa downy brome horse-weed Russian thistle wild buckwheat
Increased on Seasonlong	downy brome Japanese brome Russian thistle yellow sweetclover	Japanese brome
Increased on Twice-over rotation	annual bromes western wheatgrass	alfalfa annual bromes intermediate wheatgrass wild buckwheat
Decreased on non-grazed	alfalfa	–
Decreased on hayed	intermediate wheatgrass Japanese brome	intermediate wheatgrass yellow sweetclover
Decreased on Seasonlong	–	alfalfa downy brome intermediate wheatgrass wild buckwheat yellow sweetclover
Decreased on Twice-over rotation	wild buckwheat yellow sweetclover	–

more precipitation forage production will be higher than in drier years.

In Adams County hay production ranged from 1400 lbs/acre to 3855 lbs/acre, with a five year average of 2615 lbs/acre. In Bowman County hay production ranged from 1600 lbs/acre to 5740 lbs/acre, with a five year average of 3705 lbs/acre. In Ward County hay production ranged from 985 lbs/acre to 2100 lbs/acre, with a 4 year average of 1626 lbs/acre. The precipitation in Ward County was consistently lower than the other area involved in this study. In Stutsman County the hay production ranged from 3240 lbs/acre to 4920 lbs/acre and the five year average was 3906 lbs/acre. With the exception of Ward County hay production on the CRP grassland stands was very acceptable.

When the forage production of the grazing treatments are considered the forage production ranged from 3945 lbs/acre to 6599 lbs/acre. Utilization ranged from 33% to 64%. Range managers usually strive to graze and to leave ½ the production. In recent years the thinking has been that we can get by grazing up to 60 to 65% of the annual production. As you will note from table 1 we have been able to meet these goals with the CRP study stands. The on exception is the Ward County sit and there we have stand composition problems. There is not enough grass in some of the pastures. Renovation could certainly be considered at the Ward County site.

Table 2 shows the five year average of livestock performance at each location. These gains have been quite good in all cases. We feel that this indicates that cattle and sheep can be grazed on CRP grasslands if properly managed. We would like to emphasize that we have used moderate stocking rates and that we have grazed for 125 to 130 days each grazing season.

Tables 3-6 show the species originally planted in each of the study sites. When these stands were first planted many annual and perennial weeds are naturally a part of the stand. With grazing and haying some of the decrease. Some of the species fluctuate in the composition due to seasonal factors. In almost every case grazing and haying increseased desirable grasses. This is further evidence that grazing and haying of CRP stands can be done and is actually desirable.

When considering what type of grazing treatment or grazing system to use on CRP pastures one has to consider the other pastures used on the entire farm or ranch. Two North Dakota Extension Service Circulars (Dodds, et al. 1985 and Sedivec and Barker 1991) will be helpful in making this decision. Nyren et al., 1983 discusses the use of a complementary grazing system in western North Dakota. This grazing system would work well where the CRP pastures could be used in the Spring and Fall and native grass pastures could be used in the Summer. Natural Resources Conservation Service (NRCS) technicians and North Dakota Extension Service personel can provide expertise in this decision making.

This study has been a cooperative effort of several scientists. The Central Grasslands Research Center (CGRC) has been the area where all the data collected from the study has been deposited, analyzed, and reported. (Barker et al. 1994, Barker et al. 1994, Gross et al. 1994, Nyren et al. 1993, Nyren et al. 1993, Nyren et al. 1993. Nyren et al. 1994, Nyren et al. 1995, Nyren et al. 1995, and Sedivec et al. 1995)

Summary

A. It appears that good CRP stands can be grazed and hayed with economic success.

Qualifiers

1. One has to determine that the CRP stand has enough grass and forbs to be

grazed. CRP stands may have to be renovated if too weedy or lack adequate grass composition.

2. One needs to consider the livestock operation that the CRP stands are going to be used with. CRP stands can be successfully used as complementary pasture, seasonlong pastures , and rotational pastures. In general, we would recommend that CRP stands be used in complementary or rotation systems.

B. One will have a better grassland stand if the stand is hayed or properly grazed annually rather than have the CRP stand remain idle.

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EFFECTS OF GRAZING CONSERVATION RESERVE PROGRAM LANDS ON DUCK PRODUCTION IN NORTH DAKOTA

Kevin Sedivec, William Barker, Joseph Gross, Chad Prosser, and Paul Nyren[1]

Summary

Duck nest densities were higher (P=0.0003) on the twice-over rotation grazing system (TOR) compared to the seasonlong grazing treatment (SL) while nesting success did not differ (P=0.59). The TOR attracts significantly more ducks for nesting than the SL, with both treatments similar in nesting success. These results would indicated the TOR treatment would produce more ducklings than the SL treatments on CRP lands.

Introduction

The Conservation Reserve Program (CRP), developed in the 1985 Food Security Act, provided the incentive to take highly erodible land out of crop production and place it under permanent cover. There are approximately 36.4 million acres of land enrolled in CRP nationwide and approximately 2.9 million acres in North Dakota. The majority of these lands will either be converted into cropland or remain in the form of grassland and used as hayland or grazed when CRP contracts expire. CRP lands currently provide millions of acres of grasslands for many wildlife species including upland nesting waterfowl and gamebirds.

The NDSU Animal and Range Sciences Department started a five-year study in 1992 to look at the effects of two grazing treatments on upland nesting duck production on CRP lands in North Dakota. The primary study objectives were:

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1. To compare upland nesting bird production on a twice-over rotation (TOR) grazing system and seasonlong (SL) grazing treatment on CRP lands in central North Dakota.

2. To develop management recommendations for CRP lands incorporating proper grazing techniques that may benefit both livestock and wildlife.

Study Area and Procedures

Research was conducted at two study sites within the Missouri Coteau Physiographic Region of North Dakota. A twice-over rotation grazing system (TOR) and an adjacent seasonlong grazing treatment (SL) were compared at two study sites from 1992 through 1996. The study areas were located near Streeter and Ryder, North Dakota, in Stutsman and Ward Counties, respectively.

The Stutsman County site consisted of a 135 acre SL pasture adjacent to a three-pasture TOR grazing system. The TOR grazing system consisted of 235 acres, of with each pasture about 78 acre. The Ward County site consisted of an 80 acre SL pasture adjacent to a 208 acre three-pasture TOR grazing system, with each pasture about 70 acres.

The TOR grazing systems were divided into three pastures at each site. Cattle began grazing in mid-May and were removed from pasture after 4 months. The 1992 grazing season began in pasture one, 1993 grazing season in pasture two, 1994 grazing season in pasture three, 1995 grazing season in pasture one, and 1996 grazing season in pasture two. Cattle were rotated to the subsequent pasture after 21 days. The three pastures were grazed twice during the grazing season with each pasture receiving 42 days rest between rotations. Only one rotation was made at the Ward County site in 1992 due to the severity of the drought and lack of vegetation. The SL grazing treatment consisted of a single pasture where cattle were allowed to graze freely throughout the season.

The Stutsman county SL was stocked with 32 cow/calf pairs and the TOR with 55 cow/calf pairs during all five years of the trial. The SL and TOR stocking rates were 1.0 ac/AUM in 1992 through 1996. The Ward county SL was stocked with 16 cow/calf pairs during all five years of trial. The TOR was stocked with 47 cow/calf pairs in 1992, 1994, 1995, and 1996, and 49 cow/calf pairs in 1993. The SL and TOR stocking rates were 2.2, 1.2, 1.2, 1.2, and 1.2 ac/AUM in 1992, 1993, 1994, 1995, and 1996, respectively. Herbage degree of use was less than 50 percent on the grazing treatments at both study areas, but greater than 40 percent for all years.

Nest searches were conducted on each grazing treatment beginning May 1, May 4, May 10, May 10, and May 9 in 1992, 1993, 1994, 1995, and 1996, respectively. Four nest searches were conducted at 21-day intervals ending in mid-July and consisted of dragging a chain between two all-terrain cycles (Higgins et al. 1969, 1977). Nests were revisited every 7 to 10 days to determine their fates (Klett et al. 1986).

Nest density and success were analyzed using a block procedures using years, treatment, and study area as a block analysis. Nest density and success between treatments were tested for significant main effects using the multi-response permutation procedure (Biondini et al. 1988). Nest density and success differences by study area and year were tested using the multi-response block procedure (Biondini et al. 1988). Nest density and success were compared between the TOR and SL treatments from 1992 through 1996. The Mayfield method (Mayfield 1961, 1975) of estimating nesting success was used to determine success for all ducks on each treatment within each study area for 1992 through 1996.

Results and Discussion

Predator influences were similar between treatments at both study areas for all years. The Stutsman county site had both coyote, fox, and skunk tracks recorded on all treatments during all years of the study. The Ward county site had a high quantity of fox and skunk tracks on all treatment areas in 1992 through 1994, and 1996. In 1995, the Ward county site had a lower quantity of fox tracks on all treatments. No coyote tracks were recorded at the Ward county site. Since predator species were similar between treatments at both study area, nest densities and success could be compared.

Total number of duck nests found on the two study sites were 25, 27, 136, 145, and 151 in 1992, 1993, 1994, 1995, and 1996 respectively. Duck nest densities and success were different ($P=0.06$ and $P=0.09$, respectively) between study areas (Table 1 and 2). Overall, the TOR treatment attracted more duck nests ($P=0.0003$) than the SL treatment, averaging 12.6 nests per 100 acres or 65.7 percent of the duck nests (Table 3). The SL averaged 9.3 duck nests per 100 acres or 34.3 percent of the nests. The TOR attracted 3.3 more duck nests per 100 acres or 15.1 percent more duck nests than SL treatment.

Mayfield nesting success did not different (P=0.59) between the TOR and SL grazing treatments (Table 3). Nesting success averaged 26.5 percent on the TOR compared to 23.6 percent on the SL. Although the rotational grazing system attracted more ducks, nesting success was not affected. The presence of cattle, whether grazed seasonlong or in a rotational system, had a similar affect on nesting success.

Overall, the rotation grazing system should produce more ducks than seasonlong grazing. Since nest densities in this trial were higher on the TOR and nesting success was similar between the TOR and SL, overall duckling production should be higher on the TOR.

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Table 1. Duck nest density (number of nests per 100 acres) and percent duck nest composition found on the twice-over rotation (TOR) and seasonlong (SL) grazing treatments at the Stutsman and Ward County CRP trial, 1992-1996.

Year	Stutsman County		Ward County	
	TOR	SL	TOR	SL
1992	6.0 (57.7)	4.4 (42.3)	2.1 (100.0)	0.0 (0.0)
1993	7.2 (51.8)	6.7 (48.2)	0.4 (100.0)	0.0 (0.0)
1994	33.6 (60.2)	22.2 (39.8)	2.5 (65.8)	1.3 (34.2)
1995	33.2 (56.8)	25.2 (43.2)	3.4 (40.5)	5.0 (59.5)
1996	29.2 (56.7)	25.2 (43.3)	8.2 (68.3)	3.8 (31.7)
Mean	21.8 (56.6)	16.7 (43.4)	3.3 (74.9)	1.9 (25.1)

Table 2. Mayfield nesting success (percent) on the twice-over rotation (TOR) and seasonlong (SL) grazing treatments at the Stutsman and Ward County CRP trial, 1992-1996.

Year	TOR	SL	TOR	SL
	STUTSMAN		Ward	
1992	11.6	42.3	23.2	0.0
1993	57.7	64.8	0.2	0.0
1994	52.6	34.2	30.1	0.0
1995	21.0	34.9	53.0	39.7
1996	9.9	20.2	5.5	0.1
Mean	30.6	39.3	22.4	7.9

Table 3. Percent composition of duck nests (based on a per acre equivalent)and Mayfield nesting success on the twice-over rotation (TOR) and seasonlong (SL) grazing treatments on conservation reserve program (CRP) land in North Dakota, 1992-1996.

Treatment	Percent of[1] Total Nests	Percent Mayfield[2] Nesting Success
TOR	65.8[a]	26.5[x]
SL	34.2[b]	23.6[x]

[1]Percentages with the same letter are not significantly ($P<0.05$) different.
[2]Percentages with the same letter are not significantly ($P<0.05$) different.

Use of Melengestrol Acetate (MGA) and Estradiol 17β to Synchronize out of Season Mating in Ewes

Roger Haugen, Jim Kirsch, Wes Limesand, Larry Reynolds and Dale Redmer
NDSU Experiment Station, Fargo, 1997

INTRODUCTION

Animal agriculture must become more efficient to keep up with the ever growing demands of efficiently produced food and fiber. The sheep industry has the opportunity to fulfill 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. On the average, the number of lambs weaned per ewe per year in the nation has been one or less (CRIS, 1990).

Sheep are known to be seasonal breeders, exhibiting increased breeding activity with increasing day length. Genetically selecting breeds of sheep with less seasonal restrictions has been one method. Another method has incorporated hormones to induce breeding activity in the non-breeding season. Melengestrol acetate (MGA), an orally active synthetic progestogen, has been utilized widely in the beef cattle industry to control estrus in feedlot heifers and also as a synchronization product. Oral progestagens also have been used for estrus synchronization in the cycling ewe. The administration of medroxyprogesterone acetate (Hinds et. at. 1961) for periods of 14 to 16 days has resulted in good synchronization during the synchronized estrus. Tilton et. al. (1966) has shown that cycling ewes respond to MGA treatment with a high degree of synchrony when fed for 15 days. It was observed in some breeds such as Dorset and Rambouillet, do exhibit some cyclic activity during the non-breeding season. The percent mated and percent lambing increased over Hampshire and Suffolk sheep under the same treatment of 0.2 mg MGA/hd/day for 15 days (Tilton et. al. 1967). Quispe et. al. (1994) has shown that a significantly higher percentage of ewes (79.5%) that were fed 0.22 mg/hd/day of MGA for 14 days exhibited a synchronized estrus compared to the non-treated ewes (33.5%). Synchronization was also shown to be maintained through the second post treatment estrus, with 71.9% of the ewes exhibiting an estrus with 72 hours. Keisler, (1992) demonstrated that feeding MGA from 8 to 14 days can be used with little apparent change in response rate.

Berardinelli et. al. (1980) reported in ewe lambs that peripheral progesterone increases for a 1 to 4 day period before puberty. The source of this circulating progesterone prior to puberty is produced by luteal tissue in the ovary. Peripheral progesterone must increase during a 2 to 3 day period prior to the luteinizing hormone surge which results in the first normal 14 day luteal phase (Ryan and Foster, 1978). They suggested that the transient prepubertal rise of progesterone was caused by either premature ovulation or follicular luteinization within the ovary.

Over the past several years, an increasing number of ewes in Minnesota and North Dakota are estrous synchronized with a combination of estradiol and MGA. The basis for this treatment regimen is unclear. Because of the potential impact of adopting a more labor intensive treatment regimen than has been used previously, we designed a study to determine the benefits of using estradiol 17β in combination with MGA for out of season breeding. This study was setup to investigate if feeding MGA for 8 days with or without estradiol 17β injected at 30 hours after the last MGA feeding has any benefit in inducing a fertile synchronized out of season estrus in the ewe.

PROCEDURE

In the spring of 1995, 21 Suffolk, 20 Columbia, 20 Hampshire and 30 crossbred non-lactating ewes from age 2-5 years were fed MGA (0.25 mg/hd/day) for 8 days. At 30 hours post MGA feeding, one-half of the ewes in each group were injected intramuscularly with 20 µg estradiol 17β in sesame oil or oil alone (1 cc). Intact fertile rams were placed with the ewes at the time of injection. Rams were brisket painted daily to aid in estrous detection. Rams remained with the ewes for an additional estrous cycle. Blood samples (10 ml) were taken from each ewe by jugular puncture beginning 1 day prior to MGA treatment and continuing until 5 days after the last feeding of MGA. Progesterone, estradiol and luteinizing hormone concentrations were determined in all samples by radioimmunoassay. All blood samples were stored at -20 C until analyzed for hormone content.

In the spring of 1996, the experiment was repeated with 20 Suffolk, 20 Columbia, 20 Hampshire and 18 crossbred non-lactating ewes. Treatments were the same as in 1995 except blood samples were not collected.

Data collected was the proportion of ewes lambing, lambing data, number of lambs born, percent bred but not lambing (just 1995), number of responders (just 1995) and synchrony of estrus (just 1995).

All animals were housed at NDSU Research Facilities. MGA was purchased from a feed mill at Barnesville, MN at a cost of approximately $2.00/hd.

Lamb drop was analyzed by analysis of variance using the General Linear Models Procedure of SAS (SAS 1990). Lambing rate data were analyzed using Chi-Square.

RESULTS AND DISCUSSION

The two years data are presented in Tables 1 and 2. The first year data (Table 1) indicates that the majority of estradiol-treated ewes exhibited estrus signs, however, did not lamb to synchronization.

The analysis of both years data (Table 3) indicates that ewes fed MGA for 8 days followed by an injection of control oil had significantly more (P<.05) total ewes lambing (42.9%) due to synchronization vs. estradiol-treated (28.2%).

The lamb drop between the two treatments (Table 4) showed a trend in favor of the control group (1.44) versus the estradiol-treated group (1.32), however the difference was not significant (P>0.36) . Breed mean squares for lamb drop can be found in Table 5.

From the lambing rate data collected across both years, there is no evidence that estrogen treatment at withdrawal of MGA is useful and, if anything, may be detrimental by a potential negative effect on conception rates and/or embryo survival. The detrimental effects of steroids on gamete transport and survival have been well documented (Hafez, 1987; Harper, 1988). By using an estradiol-17β assay kit purchased with funds provided by the North Dakota Lamb and Wool Producers, estradiol-17β concentrations were determined in the blood before and after MGA treatment. Unfortunately, these kits were not sensitive enough to determine estradiol concentrations in all blood samples because of extremely low estrogen levels in sheep. We did, however, detect peak concentrations of estradiol-17β on Day 2 after withdrawal of MGA, which were similar between the control and estrogen treated groups. In the coming year, we will conduct a more extensive analysis of estradiol-17β concentrations by using an extremely sensitive in-house assay that we have validated previously (Redmer et al., 1991; Taraska et al., 1989).

Consistent with other studies (Keisler, 1992) we found a reasonable out-of- season induction of estrus by using MGA alone. Approximately 43% of the ewes lambed to out-of-season breeding induced by MGA alone. However, this still leaves about half of the ewes not responding to MGA treatment by failure to exhibit estrus following withdrawal. Therefore, our future studies will concentrate on improving these methods for induction of fertile out-of-season estrus by using various progestin treatments in combination with gonadotropin treatments to stimulate ovarian activity, as we have successfully utilized for many years in cycling ewes (Jablonka-Shariff et al., 1994; Jablonka-Shariff et al., 1996). With successful induction of out-of-season superovulation, our laboratory will begin to focus on embryo collection, culture and transfer procedures for optimizing the use of genetically superior ewes during a time when they are naturally unproductive.

Table 1. 1995 Data

	Pen 1	Pen 2	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Total
Breed	Suffolk	Hampshire	Suffolk	Columbia	Crossbred	Columbia	Hampshire	
No. of Control Ewes	5	5	5	5	15	5	5	45
No. of Control Ewes Synchronized	3	1	4	4	9	2	1	24
No. of Control Ewes Lambing from Synchronized Estrus	3 (4)	1 (2)	2 (3)	0 (0)	6 (8)	0 (0)	0 (0)	12 (17)
No. of Control Ewes Lambing from 2nd Cycle	0 (0)	2 (4)	0 (0)	2 (2)	6 (9)	1 (2)	2 (3)	13 (20)
No. Estradiol Trt Ewes	5	5	6	5	15	5	5	46
No. of Estradiol Trt Ewes Synchronized	5	4	4	3	11	4	3	34
No. of Estradiol Trt Ewes Lambing from Synchronized Estrus	1 (1)	0 (0)	0 (0)	1 (1)	3 (4)	1 (1)	1 (1)	7 (8)
No. of Estradiol Trt Ewes Lambing from 2nd Cycle	0 (0)	1 (1)	0 (0)	1 (1)	3 (6)	1 (2)	0 (0)	6 (10)

For each breed, 1 ram was exposed to 10 ewes.
( ) = Number of lambs born

Table 2. 1996 Data

	Pen 1	Pen 2	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Total
Breed	Suffolk	Hampshire	Suffolk	Columbia	Crossbred	Columbia	Hampshire	
No. of Control Ewes	5	5	5	5	9	5	5	39
No. of Control Ewes Lambing	1 (2)	2 (2)	0 (0)	3 (5)	3 (4)	1 (1)	1 (2)	11(16)
No. Estradiol Trt Ewes	5	5	5	5	9	5	5	39
No. of Estradiol Trt Ewes Lambing	1 (1)	2 (2)	1 (1)	2 (3)	3 (5)	2 (2)	0 (0)	11 (14)

For each breed, 1 ram was exposed to 10 ewes, except the 18 crossbred ewes were exposed to 2 rams..
( ) = Number of lambs born

Table 3. Lambing Rate (1995 & 1996)

	Lambed	Open	% Lambed
Control	36	48	42.9
Treated	24	61	28.2
Total	60	109	35.5

Table 4. Lamb Drop (1995 & 1996)

	Least Squares Mean	SE
Controls	1.44	0.09
Treated	1.32	0.10

Table 5. Lamb Drop by Breeds (1995 & 1996)

	Least Squares Mean	SE
Suffolks	1.31	0.17
Hampshires	1.39	0.15
Columbias	1.34	0.13
Crossbreds	1.47	0.11

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THE UTILIZATION OF NAKED OATS (PAUL OATS) IN GROWING RATIONS OF EARLY WEANED LAMBS

Roger Haugen, Wes Limesand and Bert Moore
NDSU Experiment Station, Fargo, 1997

INTRODUCTION

Alternative crops are on the rise in the region and one of those crops is naked oats (Paul oats). Naked oats has some very desirable characteristics including high digestibility, high protein and low fiber. Because of these, the possibilities of feeding naked oats to livestock has sparked interest in research trials. One such feeding possibility is in lamb growing diets.

PROCEDURE

Thirty fall born lambs (Sept-Oct of 1996) were divided into 3 pens (10 lambs /pen) on December 9, 1996. Lambs were weaned at 60 days of age. Included in the study were purebred Hampshires, Suffolks, Columbias plus crossbred lambs. Each pen had 4 males and 6 females.

One pen received a diet with 0% naked oats, the second pen received a diet containing 20% naked oats on a dry matter basis, and the third pen received a diet containing 40% naked oats on a dry mater basis. Other ingredients in the three diets were corn, soybean meal, alfalfameal, and minerals. All diets were balanced to a 16% protein basis. All diets were pelletted and self-fed.

Data being collected includes weights at each weigh period (every three weeks) plus feed utilization. The lambs will remain on test for 63 days. Evaluations will include average daily gain, feed consumption, feed conversion, and some carcass evaluation. The experiment will be repeated with 1997 spring born lambs.

MANAGING SHEEP REPRODUCTION FOR EARLY WINTER LAMBING THROUGH THE USE OF NATURAL SYNCHRONIZATION - THE RAM EFFECT

D.S. Heintz and K.A. Ringwall

INTRODUCTION

When we think of reproduction we generally think of the ewe. However, the real key to managing reproduction in sheep is managing the ram and his effect on the ewe. Reproduction in sheep can be controlled to a large extent by managing and controlling the interactions of rams and ewes throughout the year.

How can you make the sheep's natural tendencies work for you? You can naturally synchronize your ewes to come into heat within a couple of days of each other. You can use teaser rams to help shorten your lambing season. You can use natural selection so that your most productive ewes are the ones that produce your replacement ewe lambs, thereby increasing the genetic potential of your flock. We like to teach our producers practical and economical ways of increasing their flocks' productivity. Learning to manage reproduction is a very effective way to do this.

SEASONALITY OF SHEEP REPRODUCTION

Many people coming into the sheep business are frustrated that sheep don't breed year-round, and often think they need to change that to become good producers. We try to show our producers that there's often no need to change the sheep's natural cycles. Instead, we try to teach people how to make those cycles work for them. Even established producers can benefit from added knowledge about reproduction in sheep.

Sheep are seasonal breeders, just like most of the wild ruminants are. There's a reason for this. Think about the wild animals. If the wildebeests and the gazelles and all of the other wild animals had their young all throughout the year, the lions and other predators would constantly be after their young. Consequently, most of the young would be lost. However, if all of the young are born at the same time, the lions can't eat all of them. The lions come into the herd and take what they can, leaving the rest of the young to grow up and replenish the herd. Also, if wild animals bred year-round, some of them would have their young during the cold winter months, and that doesn't make much sense if they don't have access to a heated barn! Sheep have carried these traits of seasonal breeding and spring lambing from the wild into domesticity. They tend to lamb as a group, and they naturally lamb in the spring.

Most people will say that when it starts getting cool out, the ewe will start to cycle. Actually, fertility in sheep isn't controlled by temperature. Fertility is regulated by daylight. In the ewe, regulation of her fertility actually begins in the spring. As the days begin to get longer, her brain senses this and begins to set up her cycle for fall.

Figure 1 shows a diagram of the seasonality of the ewe's cycle. From some time in April through July or early August, depending on the ewe, she basically says, "There's no way I can breed." Thinking in comparison to a stoplight, we call this her "red light phase". The ewe expresses no heat and her ovaries are relatively inactive. In early August, she changes a bit and says, "If the opportunity is right, I MIGHT come into heat." We call this her "yellow light phase". Her ovaries become ready for breeding, though she's not cycling yet. During late September or in October, if the ram hasn't shown up yet, the ewe will start cycling on her own. We refer to this as her "green light phase". She's basically saying, "He hasn't found me yet, so maybe if I come into heat, he'll find me."

Like the ewe, the ram is a seasonal breeder, too. He has a season when he's ready, willing, and able to breed. The rest of the year, he's not really interested in breeding, and his fertility is reduced. In the wild, the bighorn rams keep themselves separate from the ewe herd for most of the year. They're just off in a bunch by themselves. When breeding time comes, they go into rut and then find the ewes.

Like his wild counterparts, the domestic ram also goes into rut. Several changes take place in his body and attitude as autumn approaches and length of daylight decreases. Mentally, he becomes more aggressive and interested in breeding. Physically, he appears more masculine. His face enlarges and becomes more rugged looking. The scent glands below his eyes become very large as they produce more of the scent that attracts ewes. His scrotum gets bigger as the testicles enlarge and begin producing greater amounts of sperm. If you turn the ram over and look in the areas not covered with wool, you'll notice that in most rams the skin has darkened to a red or nearly purple color. In contrast, if you look at a ram during the spring, you will notice that his head is much smoother, his scrotum is smaller, his skin tone is normal, and he smells and acts better!

TEMPERATURE AND THE RAM

Even though daylight controls the reproductive cycles, there is one situation when temperature affects the fertility of sheep. High temperatures can cause rams to become infertile. How does this happen? Normally the ram's testicles are kept at 5 to 7 degrees (F) below body temperature. This is the temperature that's best for good sperm production. The ram's body usually controls the temperature of the scrotum by letting the scrotum descend away from the body when it's hot outside. During cold weather, the scrotum is held much closer to the body.

When it gets over 90 degrees outside, the temperature of the scrotum can increase enough to inhibit sperm production. One or two days of hot weather won't make much difference in the ram's fertility. However, when it's hot and humid for long periods of time, fertility can be decreased to the point where the ram will be sterile for a while. A fever can also produce this situation.

It takes about 49 days for sperm to be produced in the ram. This means that if your ram is exposed to extended high temperatures, he may be sterile for several weeks afterward. He will become fertile again 49 days (seven weeks) after the temperature cooled down.

The best solution to this problem is prevention. Make sure your rams have a cool place during hot weather. Shearing the rams may be helpful in some cases. If you are breeding during hot weather, keep the rams cool during the day and turn them in with the ewes at night.

TEASERS

What is a teaser? It's a ram or wether that's been altered so he thinks he can breed, but he can't actually get the job done. Teasers have the same effect on the ewe that an intact ram does in terms of stimulating the ewe's reproductive cycle. The teaser works because of the effect that the scents of the male sheep have on the ewe.

Using a sterile ram at the right time is the key to naturally controlling reproduction in the ewe. The use of a teaser ram is an integral part of a natural estrus synchronization program.

There are several ways of creating teasers. You can have the vet do a vasectomy on a ram or surgically move his penis to the side so he can't enter the ewe when he mounts her. Here at the station, we prefer to use wethers as teasers. About four to six weeks before you plan to use a wether as a teaser, you can have the vet insert a testosterone implant under the skin of his neck. These implants are about the size of a finger and can be removed when you're done using the wether as a teaser. Then you have a much more manageable animal around. The vet may not have these implants on hand, so it might be good to check with him or her well before you'll need any. An important point to remember is that most rams have a "not now, dear" phase just like the ewes. Therefore, some rams will not work adequately as teasers during the spring and summer. Testosterone implants or injections may help solve this problem. Keep in mind, though that this procedure often causes the ram to become temporarily sterile.

SCENTS

The scents that sheep produce are what attracts them to one another. These scents contain substances called pheromones, which trigger sexual responses. When a ram curls up his lip and sniffs, he's actually exposing a gland under his lip that's sensitive to the ewe's pheromones. By sniffing in this way, he can locate ewes in heat.

Scents are very important to the ewe, as well. When the ewe is in her "yellow light phase" and she smells a ram for the first time in late summer or early fall, the LH (luteinizing hormone) level in her blood rises substantially. This causes her to ovulate within 40 to 60 hours of smelling the ram. The surge of LH can even be triggered by throwing a ram's fleece, which contains his scent, into a pen of ewes. The fleece is not as effective as a ram, because it can't move around and seek out each ewe, but it can still trigger ovulation.

How far away from the ewes do you need to keep the ram if you don't want the ewes to begin cycling? You sure don't want fenceline contact, but having pens a reasonable distance apart in the same operation doesn't seem to cause problems. You don't want to pen the rams and ewes close together for even a few minutes when you're working sheep, because it can foul up your efforts at natural synchronization, as you'll learn later.

ESTRUS AND THE ESTROUS CYCLE

To help avoid confusion, let's explain the difference between the words "estrus" and "estrous". The term "estrus" is a noun, and it refers to the time the ewe is in heat. As an example: The ewe is in estrus. The term "estrous" is an adjective and is used to describe the ewe's reproductive cycle. As an example: The ewe's estrous cycle is normally 17 days long.

An understanding of the ewe's estrous cycle and why she exhibits estrus are important tools in the management of reproduction. The ewe's annual cycle is depicted in Figure 1.

During her "I might come into heat" (yellow light) phase in late July and early August, the ewe's body is ready to begin the estrous cycle. However, she won't go into standing heat until she's had a silent estrous cycle. To explain this, let's show the ewe's ovary on every day of her cycle, which is normally 17 days long. (See Figure 2.)

On day one, an egg is released from the ovary. On the spot where the egg was located, a yellow area called the corpus luteum (C.L.) begins to grow. At about day five, the C.L. begins to produce the hormone progesterone. As long as the C.L. produces progesterone, the ewe won't ovulate and come into heat. At about day 14, the C.L. starts to regress, and new eggs develop on the ovaries. When the eggs are ready to be released, the cycle begins again. The ewe goes into heat on day one. Heat (estrus) lasts eight to forty-eight hours, and the eggs are released from the ovary near the end of heat.

During the ewe's first cycle in the fall, she ovulates without showing heat because the progesterone level in her system is too low to cause the hormone interactions necessary for her to come into heat. This is called a "silent estrus" because she ovulates but doesn't go into heat. However, 17 days after this silent ovulation, she'll be in heat and ready to breed.

Understanding the concept of the silent estrus may help you understand why your ewes have different lambing patterns at different times of the year. Quite often we hear the comment that during January lambing, the ewes tend to begin lambing slowly, and the majority tend to lamb toward the latter part of lambing time. In April, most people say their ewes tend to lamb all at once, and they tend to lamb at the beginning of the lambing season. The January lambing pattern shows that in August, most of the ewes weren't cycling when the ram was turned in. The presence of the ram caused the ewes to begin cycling. These ewes had a silent estrus, then bred 17 to 22 days after the ram was turned in. The April lambing pattern shows that most of the ewes were already cycling on their own in November, and they were ready to be bred when the ram was turned in.

As an example of this, let's look at a study we did on Rambouillets here in Hettinger. In August, out of 120 ewes, 12 bred during the first cycle and 108 bred during the second cycle. In November, out of 60 ewes, 48 bred on the first cycle and 12 bred during the second cycle. This showed the ram's influence in August; very few ewes were cycling before he showed up. However, in November, most of the ewes were already cycling before they were exposed to a ram.

Keeping these natural tendencies in mind will help you decide whether to use a teaser, and how much effect he's likely to have on the ewes. In general, one could expect that in August about one-fourth of the ewes may be cycling on their own, without having a ram around. By November, about three-fourths of the ewes will be cycling on their own, so the advantages are less for using a teaser in November.

NATURAL SYNCHRONIZATION

If you are planning to lamb in January, you need to get your ewes cycling in August. "Is there something in a bottle I can buy to make this happen?" you ask. You don't need to use a bottle, just your knowledge of the ewe's cycle. Most ewes won't be cycling yet in early August. They'll be in their "I might come into heat" (yellow light) phase. Their bodies are ready to cycle if they are exposed to a ram. To get the ewes to cycle, put a teaser ram in with them. Remember, within 40 to 60 hours after smelling a ram, a ewe in this phase will ovulate. That's the silent ovulation (with no heat) that starts her cycle. Fifteen or sixteen days later, take the teaser out and put the real ram in. Why 15 or 16 days? That's when the ewes will be initiating ovulation for the second time. If you wait 20 or 21 days, most of the ewes will be out of heat already. When you put your ram in after 15 or 16 days, about three-fourths of the ewes will be bred within three or four days. That's natural synchronization.

One question we're often asked at sheep school is "What about synchronizing my ewes with product X?" Synchronization is usually best done with the ram, taking advantage of the sheep's natural tendencies. It's lower in cost and labor and more reliable than artificial means if you do it in August or September. The artificial methods can also disrupt the ewe's cycle and make it difficult for her to return to a natural cycle.

Now that you've learned how to naturally synchronize ewes, you need to take a look at your operation and decide if natural synchronization is right for you. Before you decide to synchronize, you need to look at what will happen 149 days later. Will you have facilities and labor available to handle all the lambing? Synchronization can work for you or against you. Make sure you have facilities to handle all the ewes and the lambs, especially if you live in an area that's known for blizzards!

At our sheep schools, we recommend that new producers get established and learn the sheep business before they try to synchronize their ewes. The intensive, fast-paced lambing that results from synchronizing ewes might be too much for the new producer. However, a few years later some of those producers might be ready for the benefits of concise timely reproduction.

BREEDING EWE LAMBS

What about breeding ewe lambs? It's recommended that you wait to breed ewe lambs until they are at least nine months old. It's important to grow these lambs out well. Select ewe lambs born in January and February. Once they are weaned at eight weeks of age, grow them out on a fattening ration until they've reached 105 to 110 pounds. Then keep them on a 10 to 20 percent grain ration until November, when they will be old enough to breed. It's important to realize that the ewe lamb needs extra feed to grow as well as to produce lambs. Keep the bred ewe lambs separate from the older ewes. Don't make them compete for feed or they'll get pushed out.

Let's say you want to breed ewe lambs but you don't normally lamb until April. What can you do? As an example, let's say you need replacement lambs from 50 of your 300 ewes. In August, put teasers in with all 300 ewes for 15 days. Take the teasers out and put the ram in. Let him mark 50 ewes and take him out. If the ram is working, he should have mated the 50 ewes in three or four days. You'll have your replacement ewe lambs born in January, during a concise time period, and ready to be bred next November. Also, it has been shown that the best producing ewes are the ones that breed first. By allowing the ram to find these ewes for you, you're letting him select the most productive ewes to produce your replacement ewe lambs. This is a very easy selection process to help increase productivity in your flock.

BREEDING MARKS

When you put the ram in with the ewes, it's a very good idea to take breeding marks. There are harnesses and marking paints made especially for this purpose. You'll not only know when to expect your lambs, but you'll also know if your ram is working. If he's re-breeding all of the ewes he marked during the first cycle, you know he's shooting blanks and it's time to put in a different ram. It's best to discover this during the breeding season than in the spring when you have no lambs coming.

Another good reason to record breeding dates is because you'll know exactly when each ewe is due to lamb. This may help you reduce death losses in both ewes and lambs. As lambing time approaches, keep in mind that the ewe's normal gestation length is about 149 days. However, if a ewe lambs at 143 days, her lambs will probably survive. Once you've taken breeding marks and have calculated when your ewes are going to start lambing, keep this 143 day figure in mind. Be ready for lambing and start checking the ewes by 142 days. This way, if a ewe starts to go down with pregnancy disease, you'll notice it. Look at the breeding records. If she's at 143 days or later, you can induce her to lamb and perhaps save both her and the lambs. Your vet can help you with this, but you'll need to know exactly when the ewe was bred, so the vet knows how to handle the situation.

In summary, when you are managing reproduction in your sheep, it is best to keep in mind their natural tendencies. Learn to make these tendencies work for you, instead of trying to work against them. You'll probably have better results and higher profits, especially if you are a new producer.

Figure 1. SHEEP SEASONAL REPRODUCTION

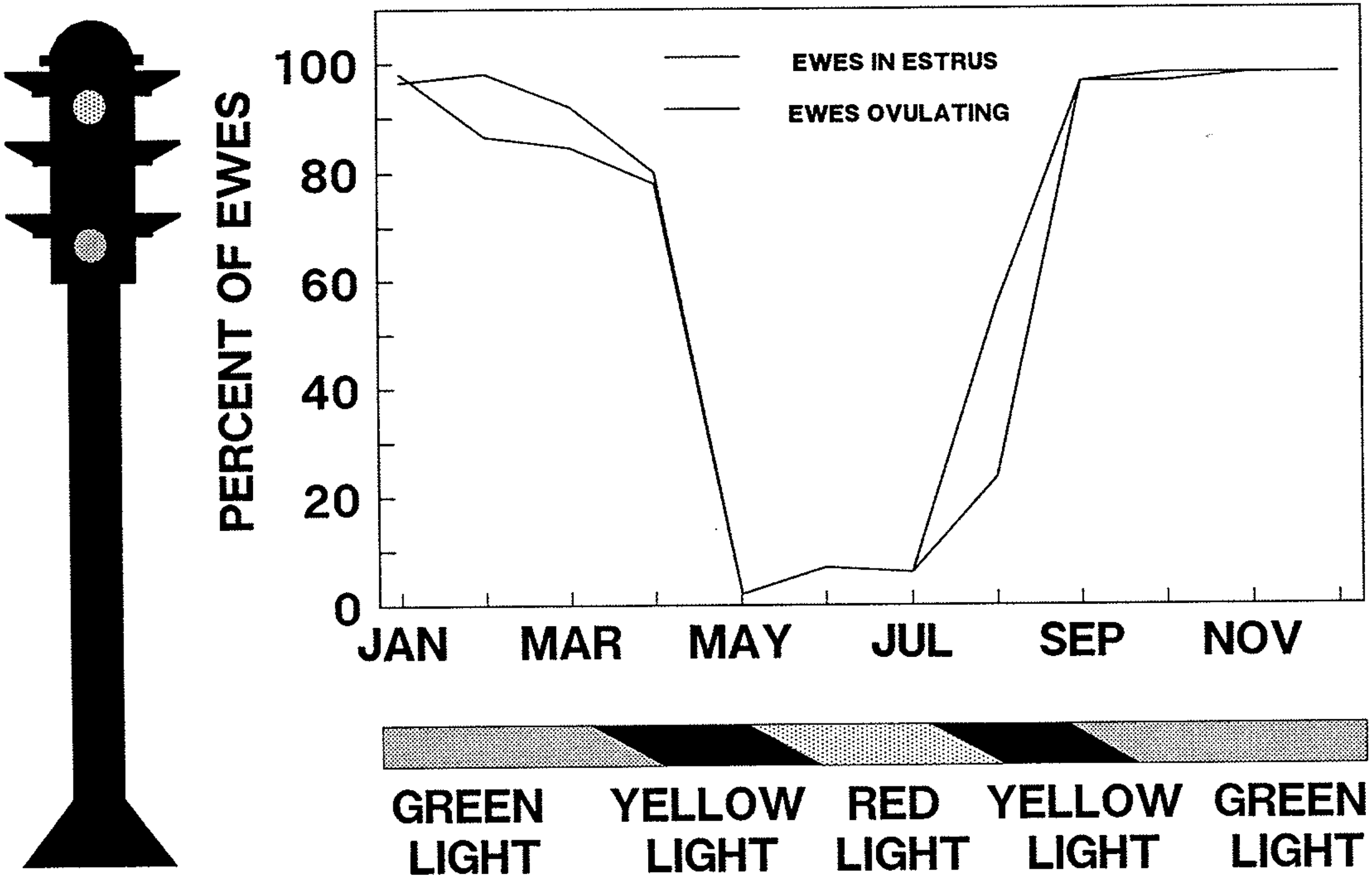
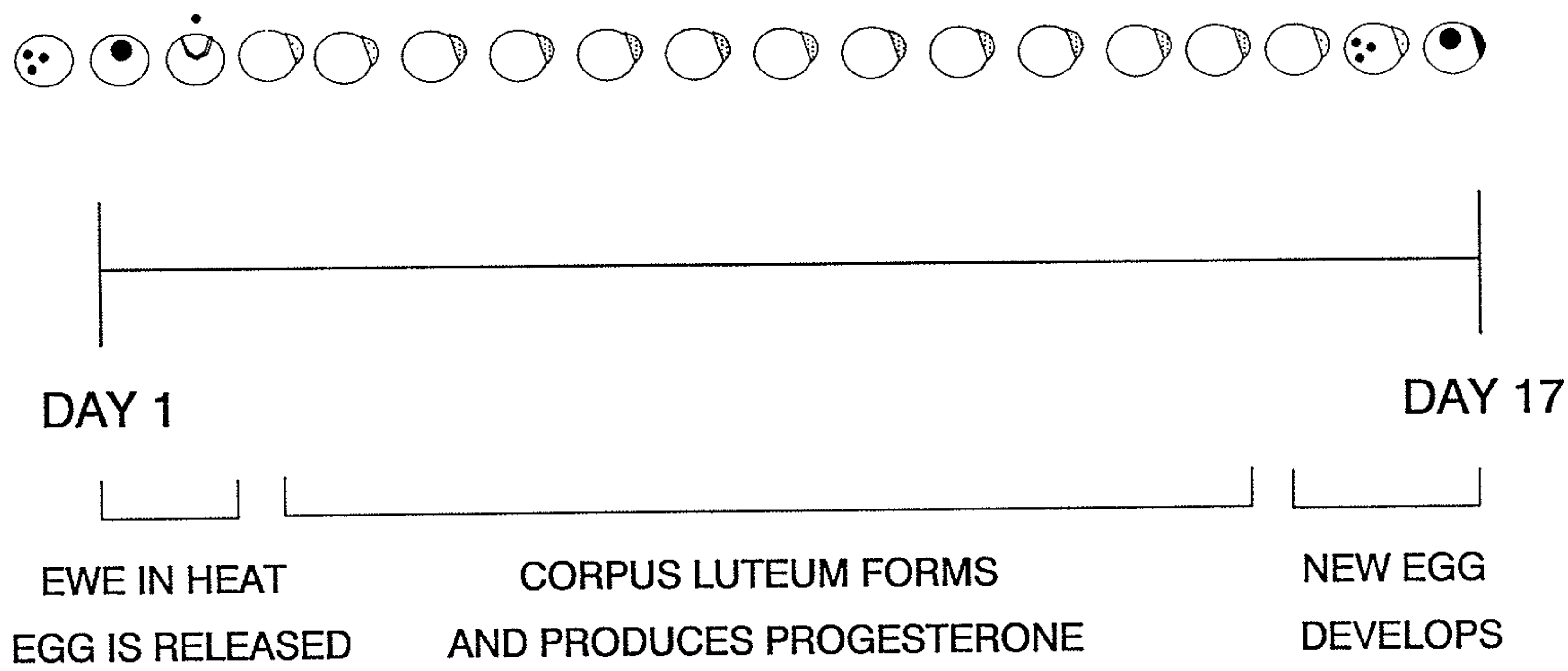


Figure 2. CHANGES IN THE EWE'S OVARY DURING THE ESTROUS CYCLE.



CRITICAL SUCCESS FACTORS IN PROFITABLE SHEEP PRODUCTION

Dan Nudell, Harlan Hughes, and Tim Faller

SUMMARY AND CONCLUSIONS

Sheep producers are faced with an almost infinite number of management decisions daily. Limited time available for management and the competing needs of other farm enterprises require that a successful producer focus his management resource on the parameters that will most affect the bottom line. This research allows sheep producers to focus on management criteria that will improve profitability and enhance the efficiency of the management resource.

Four critical success factor were identified as essential for profitable sheep production. They are 1) having a low unit cost of production, 2) having a sufficient volume of production to be efficient, 3) using the management skills necessary to efficiently utilize labor, especially at lambing, and 4) adding value to the base production of the flock.

The net profit equation suggests that producers may need to reevaluate the criteria they use to measure success. This research documented no relationship between lambing rate and profitability. Further the data collected over a several year period with wide fluctuations in market price showed no significant relationship between profitability and market price. Both lambing rate and market price are followed closely by producers with an assumed high correlation with financial success. The data suggests that producers should instead invest more time and effort into measuring and controlling the cost side of the equation. A change in unit cost of production has the most potential to change the profit picture for producers. As an added benefit the cost of production is much more easily controlled at the farm level than the market price.

Further analysis of the data suggests that current flock sizes may not be large enough to obtain optimum profits. A marginal revenue/marginal cost analysis suggests that flock size should be increased. This is supported by the fact that the elasticity of gross revenue is the second highest of the factors studied. An increase in size of production is predicted to be a positive influence on profit.

Producers also need to be aware that efficient use of labor, especially at lambing time , affects their profit potential. The sheep flock is labor intensive at lambing. A long lambing season is an inefficient use of scarce labor resources. Lambing over an extended season forces the producer to either expend labor with little return , or to scale back the level of care given the lambing ewes. Reducing labor can have a detrimental effect on profit. Death loss in lambs is identified in the subset of critical success factors and most death loss occurs in the lambing barn.

Finally, producers need to learn the skills necessary to successfully feed lambs post weaning to heavier weights. Adding value to the flock's base production is profitable. An added benefit is that the labor requirement and death loss risk is low, relative to other times of the

year, ie, the added post-weaning weight gain returns appear to be well above post-weaning costs.

CHANGES IN RECORD KEEPING NEEDED

This study's conclusions suggest that producers should focus more attention on cost of production. While not foregoing traditional records, less emphasis should be placed on the traditional production measurements of lambing rate and pre-weaning death loss. Additionally producers need to spend more management attention on knowing their cost of growing feeder lambs and their costs of weight gain on lambs after weaning.

PROCEDURE

Data from the North Dakota Sheep Development Project from the years 1988 thru 1994 was analyzed to identify measurable parameters that are controllable by the producer and have the largest impact on profitability. Production and financial information from nearly 100 flocks were tested in this research. Information on more than one hundred variables was gathered with over forty variables tested for their impact on profits in the sheep business.

The information was tested using regression analysis with the software SAS. The data was regressed using net cash profit as the dependent variable and all other parameters as potential independent variables. A four variable model, that explains 75 percent of the variation in net profits among the flocks studied, was developed.

Regression analysis is a statistical tool that allows researchers to measure the effect one or more variables, called the independent variables, have on another variable, called the dependent variable. Using this tool allowed a measurement of the effect each management practice had on the farm's net profit from the sheep enterprise. When this is done, ranking practices by magnitude of effect on profit is relatively simple.

Regression analysis identified four variables that had the largest effect on net profit. They are, unit cost of production, gross revenue, a value added component of the flock, and a measured management variable. Analysis of the nearly 100 sets of records available from the North Dakota Sheep Development Project revealed that these four critical success factors explained over 75 percent of the variation in net profit on the farms studied. In other words, producers focusing management attention on these four factors will be addressing three quarters of the potential management influenced profit change. All other possible management inputs account for less than one quarter of the variation in profit on the farms studied.

The parameters identified in the equation are 1) GROSS, which is defined as the total gross income of the flock from all sources, 2) UNIT COST OF PRODUCTION (UCOP), which is defined as the total cost of producing one unit of the primary product of the enterprise (in this case 100 pounds of market lamb), 3) VALUED, which is defined as the total amount of post-weaning weight gain in all the lambs of the flock, and 4) MGMTD, which is defined as the length of the lambing season minus the number of ewes in the flock.

The sign for GROSS is positive in the equation, that is an increase in gross revenue also causes an increase in net profit. UCOP carries a negative sign in the net profit equation. This has the opposite effect of gross, increasing the unit cost of production causes net profits to fall. The sign on VALUED is positive, more post weaning weight causes an increase in profit and the MGMTD is negative; as the lambing season lengthens profit fall.

After the four variable model of net profit was constructed, each identified critical success factor was analyzed individually to determine what influences individual management practices had on the success factor. Each critical success factor was analyzed with regression analysis and the same set of data to better understand the relationships between net profit and individual management practices. In addition a simultaneous model of elasticities of response was developed to be able to rank the management inputs by order of magnitude of response. A more complete explanation of elasticity is included in the appendix of this paper.

UNIT COST OF PRODUCTION (UCOP)

UCOP is an index of all costs and production of the flock. Unit cost of production is the factor of production with the largest elasticity of response of all variables studied. This means that a one percent change in unit cost of production changes net profit by a margin greater than a one percent change in any other variable studied. UCOP is a measure of the total cost of production of the flock divided by the total production. It is a very powerful tool as it embodies all production and all cost in a single ratio.

From the net profit equation we know that increasing the unit cost of production decreases the net profit of the flock. Three variables were identified as having strong influence on the unit cost of production. They are the total feed cost of the flock, the total weight of the lambs at weaning time and the total amount of post-weaning weight gain in the flock. In addition, the equation for UCOP contains the parameter VALUED a second time as a squared term with a positive sign. This tells us that although increasing post weaning weight gain is positive for profit there is some point where the additional weight gain becomes a detriment to profit. Increasing the feed cost for the flock raises the unit cost of production. Increasing the total weaned weight of the flock decreases UCOP. Increasing the amount of flock total post weaning weight gain decreases UCOP, to some point where it begins to increase UCOP. This is because as lambs get heavier there are increases in the amount of feed needed to add an additional pound of gain to the lambs. This change in efficiency is reflected in the model by the second VALUED term which carries a positive sign and is a squared term.

GROSS

Gross is the total income from all sources in the flock. This variable includes revenue from lamb and wool as well as sales of cull and breeding stock and government payments when received. The elasticity of gross is the second highest magnitude of the variables identified in the net profit equation.

This equation explains a large part of the variation in gross income with two variables. They are VALUED with a positive effect and MGMTD with a negative sign. The GROSS equation demonstrates that selling lambs at heavier weight has a positive effect on the flocks gross revenue which in turn is a positive influence on the flock's net profit. The equation also demonstrate the profit potential of a concise lambing season. Increases in the length of the lambing season directly reduces the flock's gross revenue and consequently the flock's profit.

MGMTD

MGMTD is a measure of the length of the lambing season compared to the size of the ewe flock. It is defined as the length of the season minus the number of ewes in the flock. A flock that has 50 ewes and lambs in 25 days would have a MGMTD value of -25. A MGMTD value of less than zero uses labor efficiently. It is also a good proxy number for good management practices used throughout the production year.

Two factors predict MGMTD in the equation. The first is the month that the first lamb is born. This may be a biological response to breeding ewes when they are most productive. The second factor is the total production level of the flock. As production levels rise, MGMTD tends to decrease. This relationship tells us that flocks using the best management techniques to have high levels of production gain a concise lambing season from the same techniques and vice versa.

VALUED

VALUED is a measurement of the amount of weight gain in the market lambs after weaning. It is a measure of how close the producer brings his lambs to final product weight. It is a positive influence on profit. Heavier weights are more profitable than lighter weights.

This parameter can be predicted with an equation of three variables. They are 1) DEATH, which is the pre-weaning flock lamb death loss percent, 2) WEAN, which is the flock total lamb weaning weight, and 3) NGCWT, which is the flock total production expressed as slaughter lamb equivalents less any government payments.

As death loss rises the critical success factor VALUED goes down. This suggests the reluctance of a producer who has already experienced high death loss to accept the risk of ownership of the lambs for a longer time. Since the majority of lamb mortality occurs in the first three days of life, most often in the first 24 hours, a lack of success at lambing time often leads to the sale of feeder lambs.

Total weaning weight is negatively related to VALUED since weaning weight is one of the defining terms of VALUED. The upper bound for lamb weight is set by the market for slaughter lambs so as weaning weight increases, the VALUED component has to be reduced.

Finally, VALUED is predicted by total production, less government payments, (NGCWT).

This relationship suggests two thoughts. First, since an increase in post-weaning weight gain by definition must increase total product produced, the two factors must move together. Another suggestion is that the producer who has the skills in all the areas necessary to have a high production level early in the production year also has the skills and confidence to retain ownership of his lambs through the feeding period to be able to market at a higher weight.

APPENDIX

EQUATIONS USED IN DETERMINING CRITICAL SUCCESS FACTORS

NET PROFIT

The calculated equation for net profit is shown below, t-values for individual parameters are in parenthesis.

$$\underset{(2.706)}{\text{NET PROFIT} = 2158} + \underset{(7.818)}{47.38(\text{GROSS})} - \underset{(-4.754)}{0.215(\text{UCOP})} + \underset{(4.634)}{0.000015(\text{VALUED})^2} - \underset{(-3.169)}{0.089(\text{MGMTD})^2}$$

The probability of the parameter being zero is less than 5 percent for all parameters. The f-value of the equation is 62.329 and the r-squared is .764. The corrected r-square is .7518.

R-square is a measure of the proportion of the total variation explained by the regression equation .An r-squared of 1 means that all the variation in the dependent variable is explained by the equation. This equation explains 76 percent of the variation in net profit results among the flocks studied.

UCOP (UNIT COST OF PRODUCTION)

The equation used to predict UCOP is below along with t-values in parenthesis.

$$\underset{(14.5)}{\text{UCOP} = 66.35} + \underset{(4.3)}{0.0064(\text{FEED})} - \underset{(-5.2)}{0.0043(\text{WEAN})} - \underset{(-3.0)}{0.0043(\text{VALUED})} + \underset{(2.9)}{0.000000117(\text{VALUED})^2}$$

All factors in the model are significant at the 5 percent level. The r-square of the equation is .3162 and the f-statistic is 8.904.

GROSS

The predictive equation for gross revenue in the flocks studied is below with t-values in parenthesis.

$$\underset{(9.4)}{\text{GROSS} = 4003} + \underset{(10.7)}{0.955(\text{VALUED})} - \underset{(-6.9)}{52.28(\text{MGMTD})}$$

In this equation VALUED is the measure of post weaning lamb weight gain for the flock and MGMTD is the relationship of lambing season to the number of ewes in the flock. Al parameters are significant at the 5 percent level, the r-square is .88 and the equation f-value is 287.7. This two factor equation explains 88 percent of the variation in gross revenue among the flocks studied.

MGMTD (A MEASURED MANAGEMENT COMPONENT)

The equation derived to predict the value of MGMTD is listed below with t-values in parenthesis.

$$\underset{}{MGMTD} = \underset{(7.76)}{91.7} - \underset{(-5.86)}{21.49(MONTH)} - \underset{(-16.93)}{0.47(NGCWT)}$$

This two factor equation has an r-square of .78 and an f-value of 143.8. All the parameters are significant at the 5 percent level.

VALUED (POST-WEANING LAMB WEIGHT GAIN)

The equation derived to predict the parameter VALUED is listed below with t-values in parenthesis.

$$VALUED = \underset{(.415)}{139.65} - \underset{(-2.699)}{55.24(DEATH)} - \underset{(-12.86)}{0.83(WEAN)} + \underset{(24.1)}{77.83(NGCWT)}$$

This equation has an r-square of .94 and an f-statistic of 422. All the parameters are significant at the 5 percent level.

MULTIPLE PRODUCTS FROM A SINGLE ENTERPRISE
THE PROBLEM OF JOINT PRODUCTS

Financial analysis of a farm enterprise often involves the issue of joint products. The definition of joint products is when a single enterprise produces more than one saleable product. For example a dairy sells not only milk, but also cull cows and calves. Sheep produce lambs, wool, cull animals, possibly breeding stock and in the past a government payment. Analysis of costs and returns from an enterprise producing joint products is more complicated than analysis of a single product enterprise.

There are three ways that joint products can be addressed. They are 1) allocation to each product by revenue percent, 2)using the main product as a proxy for all production, or 3)careful measurement of the actual costs and returns for each product.

The first possibility is to use some arbitrary method of allocating to the products. A common method would be to analyze each products contribution to the total revenue of the enterprise and allocate costs to the products in the same proportion as revenue. This method is relatively simple, fairly easy to calculate and probably fairly accurate. The downside is that we don't know for sure if the allocation is accurate.

As an alternative we can transform all products mathematically into the principle product of the enterprise and analyze the results as if the principle product was the only product. This method is also simple to calculate, in essence the total gross revenue of the enterprise is divided by the unit price of the principle product and reported as if all sales were of that product. A shortfall of this method is that fluctuations in the market price can affect the calculation of the physical product produced.

Finally we can accurately measure the inputs and outputs of each product along with the associated costs and returns for each activity and analyze using this data. While this is the most accurate method it is very difficult and prohibitively expensive.

For the analysis reported here all products were analyzed using the single product method. In this case all income and costs from the sheep enterprise were treated as if the only product was market lambs. A single product called hundred weight (CWT) equivalents of slaughter lamb was analyzed. Because for the farms in this research, over 70 percent of the income was from sales of lambs, this is the correct approach.

ELASTICITY OF RESPONSE

Elasticity analysis allows a researcher to understand how a small change in an independent variable affects the dependent variable. In this study the dependent variable is the amount of net profit in the flock and the independent variable are the management practices that affect the net profit.

Elasticity is a unitless measure of response, in other words elasticities of two parameters measures the difference in change in the dependent variable based on an equal percentage change in each individual parameter. The use of elasticities allows a manager to focus his limited input resources where they will have the greatest effect on the dependent variable he wishes to affect.

The table below suggests an order for applying management attention. Top priority should be given to managing unit cost of production (UCOP). The beauty of this result is that UCOP is entirely in the control of the producer. While it is true that the sheep producer cannot control the price of purchased input needed by the flock , the types, amounts, and timing of the use of those inputs are entirely in his control.

TABLE OF ELASTICITY VALUES OF THE CRITICAL SUCCESS FACTORS				
PARAMETER	MEAN VALUE	ELASTICITY	SIGN	CHANGE IN NET WITH 1% INCREASE IN PARAMETER
UCOP	52.9	1.36	(-)	-$25.09
GROSS	9283	1.08	(+)	$19.93
FEED	4427	0.73	(-)	-$13.42
VALUED	4158	0.66	(+)	$12.18
NGCWT	134.4	0.52	(+)	$9.64
WEAN	7207	0.39	(+)	$7.18
MGMTD	-29.9	0.19	(-)	-$3.14
MON	2.63	0.16	(-)	-$2.95
DEATH	12.9	0.05	(-)	-$0.89

MANAGEMENT STRATEGIES TO EFFECTIVELY CONTROL LEAFY SPURGE IN RANGELAND BY GRAZING SHEEP

Timothy C. Faller, Paul Berg, Dan Nudell

Introduction and Justification

North Dakota has in excess of one million acres of rangeland that is impacted by the presence of leafy spurge. Most of the land is controlled (owned or rented) by producers of beef cattle. Severity of infestation is impacted by waterways, overhead electrical transmission lines, railways and roadways. Presence of trees, high water tables, waterways and environmentally protected plant and animal species are constraints to the usage of many herbicides as useful control methods. Increasing leafy spurge populations has negatively impacted economic well-being of many livestock producers in North Dakota.

Feed costs is the largest single component of total cost of production faced by sheep producers. Birth rate and survivability of lambs from birth to weaning are critical factors impacting gross income and net profit for the sheep producer.

The opportunity to reduce variable costs and increase cash flow while adequately controlling leafy spurge in an environmentally friendly manner is attractive for many North Dakota livestock producers. Cattle are a poor utilizer of leafy spurge plants as components of the range composition while many species of wildlife and small grazing ruminants are a very good utilizer of leafy spurge as a component of the range setting. Many livestock producers truly do not want to get heavily involved in the production of alternative species of livestock (primarily sheep and goats). Management strategies that will allow them to integrate with existing sheep producers, or potentially establish profitable associated enterprises that will reduce the presence of leafy spurge are attractive to many North Dakota livestock producers. To do so they need a smorgasbord of alternatives and hard numbers to represent the income and expense of such proposed arrangements.

The North Dakota sheep industry provides in excess of $10,000,000 new wealth annually (1993 ND Ag Statistics). Loss to the North Dakota Ag Economy is estimated to be in excess of 70 million annually from the impact and costs associated with controlling leafy spurge (Leistritz, 1991). The loss of the Federal Wool Incentive program will negatively impact the future of sheep producers in North Dakota. The potential exists to reduce costs for sheep producers by providing no-cost or low cost summer grazing and in turn improving range production for the sake of enhancing impacted beef producer's incomes.

The Sheepbud Shepherd IMS enterprise analysis was developed to assist sheep producers evaluate the economics of their operation (Nudell, 1994). Sheepbud Shepherd IMS is presently being S.P.A. tested and will be available to be used as a method of cross referencing the different strategies developed to control leafy spurge in the rangeland.

Experimental Procedure

Actual production associated with a variety of research trials at Hettinger Research Center will be evaluated economically to provide numerous strategies to be presented to industry for application. The strategies will address three different primary approaches to incorporating small ruminant animals in grazing plans focused on controlling leafy spurge. The strategies will be categorized on the basis of intensity of sheep production. Primary focuses will be: High Intensity (HI), Traditional Approaches (TI) and Low Intensity (LI). Data will be collected on; longevity, lamb survivability and routine production measures. An initial flock of 400 ewes will be established composed of 200 each of rambouillet and Montadale x Rambouillet ewes. Half of each group will be born in 1993 and the other half in 1994. Similar breed type yearling replacement ewes will be added annually to keep numbers relatively constant. Similar numbers from each year and breed type will be initially assigned to each of five management strategies. The five management strategies will be compared to an existent accelerated lambing flock of 500 ewes (HI).

High Intensity Approach (HI)

Rambouillet ewes and rams will be utilized to increase the incidence of out of season mating. The attempt will be to select all replacements from fall born lambs of a closed flock of 500 ewes. Ewes will be mated and allowed to lamb in January and September as often as possible. Presently this flock of ewes is lambing at 1.4 lambings annually and presenting 1.5 lambs per lambing. This provides in excess of two lambs born per ewe annually. A 56 day weaning strategy will allow ewes to graze leafy spurge infested rangeland without the presence of lambs to reduce losses to predators under both lambing times. Both sets (January lambing and September lambing ewes) will summer graze leafy spurge at the Missouri River Correctional Center (MRCC), Bismarck, North Dakota. The High intensity group will be limited to fall born ewes which are similar age to the ewes in the other groups.

Traditional Approach (TI)

Rambouillet and Montadale x Rambouillet cross ewes that lamb in January and are exposed to lamb once annually with resulting production to be weaned at 60 days of age and put in the feedlot will be compared to genetically similar ewes that will lamb in April-May, weaning weights will be taken at 60 days. Both groups will be shed lambed with half to be reared in confinement and half in outside lots.

Low Intensity Approach (LI)

Rambouillet and Montadale x Rambouillet cross ewes of similar genetic background to the TI group will be mated to begin lambing mid-may. The intent is to begin lambing on the range at the onset of the time ewes begin grazing leafy spurge. The intent of this group is to measure if the sheep operation can support itself with the primary interest being to improve the range resource for the benefit of the beef cow. Also of interest will be observing the bonding mechanism as described at the Jornada Experiment Range site in New Mexico. Bonding of sheep to cattle would be of advantage to sustaining the sheep component of this strategy.

Economic Procedure

The approach will be to measure actual production figures and imply sound economics using the Sheepbud Shepherd IMS financial analysis program to cross reference comparisons.

Duration

The data accumulated from five lambing years for each of the strategies will be utilized to evaluate economic viability of the treatments. Data from the multi-species trial will be utilized to measure effectiveness of leafy spurge control and the impact on species composition at the site. (Economic impact should be known in five years, however, it may take longer to acquire full knowledge of impact on the range site.)

1996 Results and Discussion

The results presented are preliminary and provided for discussion only. A detailed systems evaluation of the data will be conducted at the conclusion of the project. Tables 1-6 represent performance data for the ewes of the five management systems for the years 1995 and 1996. Tables 1 and 2 give production information for the various ewe types and management systems lambing in the project. Tables 3 and 4 indicate performance of the lambs born in the project to a 60 day weaning time. Lambs born and reared on grass were weighed at a similar date and left on the ewe. Table 5 indicates reproductive performance of a similar age group of Rambouillet ewes HI on an accelerated lambing project as a control and table 6 the performance of those HI generated lambs.

Tables 7-11 merge data to look at some other questions that have been popular producer questions. Again this assembly of data is for discussion purposes only as it will require at least three full years of data to analyze this information statistically.

Table 7 merges data for the years 1995 and 1996 for the purpose of comparing breed, lambing time and system. Table 8 merges lambing times to compare breed and system. Table 9 merges breed types and lambing time to make a comparison of systems. Table 10 merges breed type and system to compare lambing times for the MI systems and further compares that to the LI system. Table 11 merges systems and lambing time to compare breeds. The HI control group data is not incorporated in any of the merged data sets.

Table 1. Reproductive performance of Rambouillet ewes under five different rearing strategies.

	JANUARY LAMBING				MAY LAMBING					
	1995		1996		1995			1996		
BREED TYPE	RXR	RXR	RXR	RXR	RXR	RXR	RXR	RXR	RXR	RXR
REARING TYPE	IN	OUT	IN	OUT	IN	OUT	PAST	IN	OUT	PAST
EWE AGE @ LAMBING IN MONTHS	20	20	26	26	24	24	24	30	30	30
EWES EXPOSED	20	20	40	39	20	20	21	34	38	34
EWES LAMBING	17	20	35	36	19	19	21	32	36	30
DRY EWES*	3	0	5	3	1	1	0*	2	2	4
LAMBS BORN	29	31	60	60	33	34	25	52	52	39
LAMBS WEANED	21	27	51	50	26	22	18	32	35	33
LAMBS WEANED PER EWE EXPOSED	1.05	1.35	1.28	1.28	1.30	1.10	.86	.94	.92	.97
PERCENT REARED OF THOSE BORN	72	87	85	83	79	65	72	61	67	97

R = RAMBOUILLET
M = MONTADALE
PAST = PASTURE
IN = CONFINEMENT REARING
OUT = BARN AND LOT REARING
* NO RECORD
* ULTRASOUND UTILIZED TO DIAGNOSE DRY EWES ('96)

Table 2. Reproductive performance of Montadale-Rambouillet cross ewes under five different rearing strategies.

	JANUARY LAMBING				MAY LAMBING					
	1995		1996		1995			1996		
BREED TYPE	MXR	MXR	MXR	MXR	MXR	MXR	MXR	MXR	MXR	MXR
REARING TYPE	IN	OUT	IN	OUT	IN	OUT	PAST	IN	OUT	PAST
EWE AGE @ LAMBING IN MONTHS	20	20	26	26	24	24	24	30	30	30
EWES EXPOSED	18	18	38	35	18	18	18	35	35	32
EWES LAMBING	15	16	33	31	17	17	18	35	35	29
DRY EWES*	3	2	5	4	1	1	0*	0	0	3
LAMBS BORN	25	27	42	40	22	24	21	44	44	32
LAMBS WEANED	19	21	36	35	20	20	18	30	32	29
LAMBS WEANED PER EWE EXPOSED	1.06	1.17	.95	1.00	1.11	1.11	1.00	.87	.91	.91
PERCENT REARED OF THOSE BORN	76	78	86	88	91	83	86	68	73	91

R = RAMBOUILLET
M = MONTADALE
PAST = PASTURE
IN = CONFINEMENT REARING
OUT = BARN AND LOT REARING
* NO RECORD
* ULTRASOUND UTILIZED TO DIAGNOSE DRY EWES ('96)

Table 3. Performance of lambs born of Rambouillet ewes reared on five different strategies.

	JANUARY LAMBING				MAY LAMBING					
	1995		1996		1995			1996		
BREED TYPE	RXR	RXR	RXR	RXR	RXR	RXR	RXR	RXR	RXR	RXR
REARING TYPE	IN	OUT	IN	OUT	IN	OUT	PAST	IN	OUT	PAST
WEAN WT (lbs)	43.43	52.96	47.08	45.78	35.46	37.73	39.39	24.8	28.8	39.0
WEAN AGE DAYS	72.57	67.15	63.45	62.74	56.62	57.18	56.9	41.4	42.4	41.9
WEAN WEIGHT CORRECTED TO 60 DAYS (lbs)	36.0	47.4	44.5	43.8	37.8	39.6	41.4	36.0	40.8	55.8
POUNDS LAMB WEANED PER EWE EXPOSED @ 60 DA	37.8	64.0	56.8	56.2	49.1	43.6	35.5	33.8	37.5	54.1

R = RAMBOUILLET
M = MONTADALE
WEAN AGE IN BOLD PRINT CALCULATED FROM AVERAGE OF OTHER SIMILAR GROUPS.

Table 4. Performance of lambs born of Montadale-Rambouillet cross ewes reared on five different strategies.

	JANUARY LAMBING				MAY LAMBING					
	1995		1996		1995			1996		
BREED TYPE	MXR	MXR	MXR	MXR	MXR	MXR	MXR	MXR	MXR	MXR
REARING TYPE	IN	OUT	IN	OUT	IN	OUT	PAST	IN	OUT	PAST
WEAN WT (lbs)	45.11	51.48	48.83	46.64	38.15	35.03	44.06	30.2	33.6	42.0
WEAN AGE DAYS	66.79	70.67	59.08	61.54	58.5	57.85	58.18	45.0	44.8	44.9
WEAN WEIGHT CORRECTED TO 60 DAYS (lbs)	40.8	43.8	49.8	45.6	39.0	36.6	45.6	40.3	44.9	56.2
POUNDS LAMB WEANED PER EWE EXPOSED @ 60 DA	43.1	51.1	47.2	45.6	43.3	40.7	45.6	35.0	40.9	51.1

R = RAMBOUILLET
M = MONTADALE
WEAN AGE IN BOLD PRINT CALCULATED FROM AVERAGE OF OTHER SIMILAR GROUPS.

Table 5. Reproductive performance of Rambouillet ewes HI on an accelerated lambing strategy.

BREED TYPE	RXR	
	1995	1996
LAMBING TIME	JAN/SEPT	JAN/SEPT
REARING TYPE	IN/OUT	IN/OUT
EWE AGE @ LAMBING TIME MONTHS	16/24	16/24
TOTAL EWES	98	121
EWES LAMBING	63/59	89/67
DRY EWES (BOTH LAMBINGS)	14	8
LAMBS BORN	81/88	114/90
LAMBS WEANED	64/76	90/86
% REARED OF THOSE BORN	79/86	79/95

R = RAMBOUILLET
IN = CONFINEMENT REARING

Table 6. Performance of lambs born of Rambouillet ewes HI on an Accelerated lambing strategy.

BREED TYPE	RXR	
	1995	**1996**
LAMBING TIME	JAN/SEPT	JAN/SEPT
WEAN WEIGHT (LBS)	39.29/42.91	44.7/32.68
WEAN AGE (DAYS)	64.35/65.22	62.9/56.18
WEAN WT CORRECTED TO 60 DAYS (LBS)	36.6/39.6	42.6/34.9
TOTAL LBS OF LAMB PRODUCED PER EWE @ 60 DAYS (LBS)	56.57	56.49

R = RAMBOUILLET
* =EXTREMELY WET CONDITIONS IN LOTS

Table 7. Merged data for the years 1995 and 1996 for the purpose of comparing breed, lambing time and system.

	JANUARY LAMBING				MAY LAMBING					
BREED TYPE	MXR	MXR	RXR	RXR	MXR	MXR	MXR	RXR	RXR	RXR
REARING TYPE	IN	OUT	IN	OUT	IN	OUT	PAST	IN	OUT	PAST
EWES EXPOSED	56	53	60	59	53	53	51	54	58	55
EWES LAMBING	48	47	52	56	52	52	47	51	55	51
DRY EWES	8	6	8	3	1	1	3	3	3	4
LAMBS BORN	67	67	89	91	66	66	51	85	86	64
LAMBS WEANED	55	56	72	71	50	52	47	58	57	51
LAMBS WEANED / EWES EXPOSED	.98	1.08	1.20	1.30	.94	.98	.92	1.07	.98	.93

Table 8. Merged lambing times to compare breed and system.

	BREED TYPE AND SYSTEMS					
BREED TYPE	MXR	MXR	MXR	RXR	RXR	RXR
REARING TYPE	IN	OUT	PAST	IN	OUT	PAST
EWES EXPOSED	109	106	51	114	117	55
EWES LAMBING	100	99	47	103	111	51
DRY EWES	9	7	3	11	6	4
LAMBS BORN	133	133	53	174	177	64
LAMBS WEANED	105	108	47	130	134	51
LAMBS WEANED/ EWE EXPOSED	.96	1.02	.92	1.14	1.14	.92

Table 9. Merged breed types and lambing time to make a comparison of systems.

	LAMBING SYSTEMS		
	IN	OUT	PAST
EWES EXPOSED	223	223	106
EWES LAMBING	203	210	98
DRY EWES	20	13	7
LAMBS BORN	307	310	117
LAMBS WEANED	235	242	98
LAMBS WEANED / EWE EXPOSED	1.05	1.08	.92

Table 10. Merged breed type and system to compare lambing times for the MI systems and further compares that to the LI system.

	LAMBING TIME AND SYSTEM		
	MI		LI
	JAN (IN & OUT)	MAY (IN & OUT)	MAY (PAST)
EWES EXPOSED	228	218	106
EWES LAMBING	203	210	98
DRY EWES	25	8	7
LAMBS BORN	314	303	117
LAMBS WEANED	254	217	98
LAMBS WEANED / EWE EXPOSED	1.11	.99	.92

Table 11. Merged systems and lambing time to compare breeds. The HI control group data is not incorporated in any of the merged data sets.

	BREEDS	
	MXR	RXR
EWES EXPOSED	266	286
EWE LAMBING	246	265
DRY EWES	19	21
LAMBS BORN	319	415
LAMBS WEANED	260	315
LAMBS WEANED/ EWE EXPOSED	.98	1.10

Summary

Environmentally the need is to control leafy spurge with reduced reliance on herbicide exists. This research is needed to preserve the role of the sheep industry in North Dakota agriculture and to improve the economic viability of impacted beef producers.

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SECTION II

GUEST SPEAKER SECTION

PRESENTED BY

PAUL NYREN, DIRECTOR
CENTRAL GRASSLANDS RESEARCH CENTER
STREETER, NORTH DAKOTA

DR. GARY SNOWDER
U.S. SHEEP EXPERIMENT STATION
DUBOIS, IDAHO

AT THE

38TH ANNUAL SHEEP DAY

HETTINGER RESEARCH EXTENSION CENTER
HETTINGER, NORTH DAKOTA

FEBRUARY 12, 1997

An Economic Analysis of Grazing, Haying and Cropping Systems on CRP Land in Southcentral North Dakota

By Paul E. Nyren, Bob D. Patton, Brian S. Kreft and Cole Gustafson

The Conservation Reserve Program (CRP) began with the 1985 Farm Bill for the purpose of taking highly erodible land out of production for 10 years. Now, the 10-year contracts have expired and millions of acres of these lands will be returned to crop production or grazing. Decision time is here. Will the contracts be renewed? If not, will it be more profitable to maintain the land in grass for grazing or haying, or, will the land be returned to annual cash crop farming? In anticipation of this decision, a study comparing the economic returns from these options was begun at the Central Grasslands Research Center in 1992. Designed to provide guidelines for Coteau area producers in making this management decision, the project includes the following comparisons:

1. Cash crop farming using a four-year rotation of sweetclover, oats for grain, wheat, and barley.
2. Oat-sweetclover rotation of sweetclover, followed by oats underseeded to sweet-clover, either cut for hay or harvested for grain.
3. Grazing CRP land.
4. Haying CRP land.

Cash Crop Farming and Oat-Sweetclover Rotation

Forty acres of previously cropped land located on the CGRC are used for the cash crop and forty adjacent acres are used for the oat-sweetclover rotation. Costs of farming and forage harvesting operations are custom rates from extension circular *Custom Farm Work Rates (EC 499)*. Other costs are best estimates. All costs were figured and tabulated in the year they occurred (table 1). Potential value of the land to the owner is included in the analysis and is the rental value as published annually in *North Dakota Agricultural Statistics*. Since the cropping part of the study is located in Kidder County and the grazing and haying on CRP land is nearby in Stutsman County, the cropland rental rates were averaged for the two counties and used as the cropland cost. The returns to each of the enterprises reflect the costs of the land, i.e. the return to the crop rotation in 1996 was $5.23 which includes a land cost of $27.25/acre (table 2). It will come as no surprise to see that returns from both cash crop farming and the oat-sweetclover rotation are as dependent upon Mother Nature and the vagaries of the market as they are on good farm management. It is also important to remember that in this analysis, custom rates are being charged against returns. The profit side of custom work and the somewhat inflated land rental values will modify the net returns per acre considerably.

Grazing CRP Land

Three hundred and seventy acres of privately owned CRP land located 4 miles southeast of the Center are used for grazing. This land was seeded in 1985 to a mixture of tall wheatgrass, intermediate wheatgrass, sweetclover and alfalfa, and is now subdivided into a season-long treatment and a twice-over rotation treatment. The economic returns from both grazing systems are combined in this study.

For the purpose of this study, the livestock and CRP land enterprises are combined. Economic principles would suggest that each be separated, but because we are evaluating a system of grazing CRP land we have combined them into one enterprise. The land rental value would range from $10.80 to $27.25 depending on whether the land was pastured or cropped in 1996.

The value of the livestock inventory at the beginning and end of each calendar year is included in the livestock budget (table 3). This inventory includes animals purchased during the year which could be sold and converted to cash at any time. It was assumed that the entire herd of bred females was purchased on January 1, 1992. Since there were no replacement females in the CRP herd in 1993, it was necessary to purchase 17 replacements. In 1994, 1995 and 1996, seventeen heifers saved from the 1992, 1993 and 1994 calf crops were ready to calve and became the replacements.

The livestock inventory affects the returns to the operation because the value of the females on hand fluctuates during the year. As table 3 shows, the herd was valued at $79,608.43 at the end of 1993 but was worth only $69,836.51 on December 31, 1994. This change in the livestock value was recorded as a –$9,771.92 in table 5 under inventory change. In 1995 cattle prices declined again and the herd value dropped to $63,317.92 by the end of the year. Consequently, the livestock inventory change for 1995 showed a –$6,518.59. In 1996 cattle prices increased slightly and the herd value totaled $65,673.90 resulting in a positive livestock inventory change of $2,355.98.

Table 4 is a listing of the costs associated with operating the livestock herd during the year. The cost of replacements is the cost of maintaining the replacement heifers from the time of weaning until they join the herd. This includes pasture costs during the summer and feed costs for the time they are kept separate from the main cow herd. Cost for herd sires is similar to the replacement budget. Annual per acre costs for maintaining a cow for five years of the study varied only slightly, from a low of $75.43 in 1995 to $83.96 in 1994.

Table 5 shows the value of animals sold during the five years of the trial. Each year it was assumed that 17 heifer calves were retained as replacements and 17 cows sold as culls. The value of the animals was calculated at the time of weaning in consultation with a local cattle buyer who is familiar with the herd. Each year an opportunity cost was deducted from the returns from livestock sales. This is the amount of interest that could have been earned if the livestock had been sold and the money invested at simple passbook interest for the year. Net return per acre for the five–year study varied from a high of $5.82 in 1993 to –$21.39 in 1995.

Haying CRP Land

Ninety acres of CRP land adjacent to the grazing systems are cut for the hay crop. These were also seeded in 1985 to the same species used in the grazing study. Costs and returns for haying

CRP land are shown in table 6. In 1992 the 90 acres of CRP hayland produced 403 bales averaging 1100 pounds. The quantity produced was the result of haying a field that had not been cut since 1985. The quantity was high but the quality was low, resulting in a lower return than for average grass-alfalfa hay for that year. In 1993 the quality was better since much of the old material had been removed. However, the value of the hay in the wet year of 1993 was about the same. In 1994 both quantity and quality increased and returns were appreciably higher than in 1993. Due to above-average precipitation in 1995, production increased to 288 bales averaging 1400 lbs/bale. Hay production in 1996 decreased to 236 bales each weighing 1300 lbs. Due to the abundance of hay on the market, hay prices dropped to $28/ton. The average net return per acre for the five-year period was –$1.50.

Conclusions

Table 7 summarizes the net return to each management system or enterprise. This is the amount of profit or loss after the value of the land and labor are deducted. Also listed is a return to land, labor, and management for producers who do not want to consider renting their land or charging for their labor. The cost of labor on the cropping and haying systems was not deducted because it could not be separated from the custom work rate. As already observed, returns from all systems are as dependent upon weather and current prices as they are on good farm-ranch management.

Cost figures shown in tables 1, 4, and 6 for custom work, land rental and cow maintenance are from *Ag Statistics*, Ag Extension publications, or are best estimates. In any given operation, the poorest cropland was enrolled in the CRP. When making decisions for future use of these acres, it is important to remember that this land will always be marginal in quality; therefore, each producer should substitute his costs of operation to arrive at his potential net profit or loss. Government payments should not be included in this estimate.

Should you cash rent your land? On land valued at $240/acre, cash rent of $27.25/acre is a 11.35% return on investment. This would indicate that land rental rates are too high in relationship to the land's ability to return a profit. Results of this study to date show grazing and hay production to be the most profitable options. Consideration should also be given to additional uses such as wildlife easements or fee hunting.

Table 1. Costs/Acre For Cropland

Cash Crop Rotation

	Sweetclover 1992	Oats 1993	Wheat 1994	Barley 1995	Wheat 1996
Seed	$3.36	$2.01	$8.12	$5.25	$10.65
Fertilizer	$0.00	$6.45	$3.55	$20.21	$6.62
Herbicide	$0.00	$7.13	$9.16	$34.07	$15.81
Herbicide Application	$0.00	$2.50	$2.48	$5.70	$2.85
Deep Chisel	$2.14	$5.00	$4.28	$4.93	$4.93
Field Cultivation	$2.09	$5.00	$4.17	$5.44	$4.13
Seeding	$2.62	$5.00	$5.24	$5.24	$6.00
Swathing	$4.23	$4.00	$4.23	$4.23	$4.37
Mowing	$0.00	$0.00	$0.00	$0.00	$0.00
Land Costs	$26.90	$26.20	$27.45	$26.05	$27.25
Piling & Packing	$2.09	$0.00	$0.00	$0.00	$0.00
Harvesting	$8.77	$12.00	$12.59	$12.59	$13.72
Hauling	$4.95	$5.09	$1.80	$3.55	$2.44
Rock Picking	$0.00	$0.00	$0.00	$0.00	$0.00
Total Cost	**$57.15**	**$80.38**	**$83.07**	**$127.26**	**$98.77**

Oat-Sweetclover Rotation

	Sweet clover 1992	Oat Hay 1993	Sweet clover 1994	Oat Grain 1995	Sweet clover 1996
Seed	$3.36	$6.28	$0.00	$7.75	$0.00
Fertilizer	$0.00	$6.45	$0.00	$5.78	$0.00
Herbicide	$0.00	$0.00	$0.00	$0.00	$0.00
Herbicide Application	$0.00	$0.00	$0.00	$0.00	$0.00
Deep Chisel	$2.14	$5.00	$0.00	$4.93	$0.00
Field Cultivation	$2.09	$5.00	$0.00	$4.13	$0.00
Seeding	$2.62	$5.00	$0.00	$5.24	$0.00
Swathing	$4.23	$5.00	$6.34	$4.23	$4.37
Mowing	$0.00	$0.00	$0.00	$0.00	$0.00
Land Costs	$26.90	$26.20	$27.45	$26.05	$27.25
Piling & Packing	$2.09	$0.00	$0.00	$0.00	$0.00
Harvesting	$8.77	$12.50	$15.81	$12.59	$9.71
Hauling	$4.95	$2.50	$3.25	$2.64	$3.66
Rock Picking	$0.00	$0.00	$0.00	$0.00	$0.00
Total Cost	**$57.15**	**$73.93**	**$52.85**	**$73.34**	**$44.99**

Table 2. Returns From Cropland

	Cash Crop Rotation				
	1992	1993	1994	1995	1996
Acres	40	40	40	40	40
Crop	Sweet clover	Oats	Wheat	Barley	Wheat
Yield-bu. or Tons/A	2.025	57.81	20	39	26
Price/bu. or/Ton	$21.10	$1.16	$2.75	$1.80	$4.00
Deficiency Payment	$0.00	$0.15	$0.50	$0.00	$0.00
Gross Return/A	$42.73	$75.73	$64.29	$70.20	$104.00
Total Cost/A	$57.15	$80.38	$83.07	$127.26	$98.77
Net Return/A	**–$14.42**	**–$4.65**	**–$18.78**	**–$57.06**	**$5.23**

	Oat-Sweetclover Rotation				
	1992	1993	1994	1995	1996
Acres	40	40	40	40	40
Crop	Sweet clover	Oat Hay	Sweet clover	Oat Grain	Sweet clover
Yield-bu. or Tons/A	2.025	1.75	2.09	29	1.2
Price/bu. or/Ton	$21.10	$35.00	$40.00	$1.30	$28.00
Deficiency Payment	$0.00	$0.00	$0.00	$0.00	$0.00
Gross Return/A	$42.73	$61.25	$83.60	$37.70	$33.60
Total Cost/A	$57.15	$73.93	$52.85	$73.34	$44.99
Net Return/A	**–$14.42**	**–$12.68**	**$30.75**	**–$35.64**	**–$11.39**

Table 3. Livestock Inventory					
	1992	1993	1994	1995	1996
Beginning Inventory	$0.00	$72,621.65	$79,608.43	$69,836.51	$63,317.92
No. Purchased	87	17	0	0	0
Cost/Hd	$850.00	$875.00	$0.00	$0.00	$0.00
Purchase Value	$73,950.00	$14,875.00	$0.00	$0.00	$0.00
Begin Inv+Purch (+$5,400 for bulls in 1992)	$79,350.00	$87,496.65	$79,608.43	$69,836.51	$63,317.92
No. Steers Born	46	41	55	49	42
No. Heifers Born	41	46	32	38	45
Steers Sold	46	41	55	49	42
Heifers Sold	24	29	15	21	28
No. Culls Sold	17	17	17	17	17
End Inventory Cows	$67,821.65	$70,180.76	$64,167.27	$56,550.00	$57,960.00
Replacement Inv.	$0.00	$5,227.67	$2,069.24	$1,967.92	$3,513.90
Value of Bulls	$4,800.00	$4,200.00	$3,600.00	$4,800.00	$4,200.00
Ending Inventory	**$72,621.65**	**$79,608.43**	**$69,836.51**	**$63,317.92**	**$65,673.90**
Inventory Change	**-$6,728.35**	**-$7,888.22**	**-$9,771.92**	**-$6,518.59**	**$2,355.98**

Table 4. Costs Per Cow					
	1992	1993	1994	1995	1996
No. Of Head	87	87	87	87	87
No. Of Acres	370	370	370	370	370
Fuel & Elec.	$36.90	$37.64	$37.70	$37.90	$39.04
Dep. Bldg Eq.	$14.56	$14.85	$14.90	$14.90	$14.95
Feed	$114.72	$86.04	$101.64	$73.80	$68.88
Salt & Mineral	$9.00	$9.05	$9.08	$9.12	$9.39
Replacements	$16.15	$33.18	$31.07	$30.13	$30.60
Bull	$11.43	$9.90	$10.55	$9.84	$17.19
Veterinary	$5.25	$5.30	$5.40	$5.45	$5.61
Marketing	$4.00	$4.00	$4.00	$4.00	$4.00
Labor	$16.78	$16.85	$16.85	$16.85	$16.85
Land Costs	$114.40	$111.43	$116.74	$110.79	$115.89
Death Loss	$9.12	$10.06	$9.15	$8.03	$6.59
Total/Cow	**$352.31**	**$338.29**	**$357.08**	**$320.81**	**$328.99**
Total/Acre	**$82.84**	**$79.54**	**$83.96**	**$75.43**	**$77.36**

Table 5. Livestock Returns/Acre					
	1992	**1993**	**1994**	**1995**	**1996**
No. Heifers	24	29	15	21	28
No. Acres	370	370	370	370	370
Avg. Wt.	497.0	526.8	576	524	443
Price/Lb.	$0.90	$0.85	$0.73	$0.62	$0.62
Returns-Heifers					
(less 5% shrink)	$10,198.44	$12,336.34	$5,986.64	$6,481.36	$7,305.96
No. Steers	46	41	55	49	42
Avg. Wt.	539.5	577.0	622.0	562	466
Price/Lb.	$0.95	$0.90	$0.78	$0.65	$0.66
Returns-Steers					
(less 5% shrink)	$22,397.34	$20,226.73	$25,349.61	$17,004.71	$12,271.64
No. Culls	17	17	17	17	17
Avg. Wt.	1280	1372	1336	1346	1212
Price/Lb.	$0.45	$0.45	$0.46	$0.30	$0.32
Returns-Culls					
(less 5% shrink)	$9,302.40	$9,971.01	$9,921.43	$6,521.37	$6,263.62
Total Returns	**$41,898.18**	**$42,534.08**	**$41,257.68**	**$30,007.44**	**$25,841.22**
Inventory Change	−$6,728.35	−$7,888.22	−$9,771.92	−$6,518.59	$2,355.98
Opportunity Costs.	$3,967.50	$3,062.38	$3,980.42	$3,491.83	$2,865.90
Total Herd Costs	$30,650.80	$29,431.38	$31,065.61	$27,910.09	$28,622.46
Total cow cost/A (table 4)	$82.84	$79.54	$83.96	$75.43	$77.36
Net Returns/Acre	**$1.49**	**$5.82**	**−$9.62**	**−$21.39**	**−$6.62**

Table 6. Costs and Returns for CRP Hay

	1992	1993	1994	1995	1996
Acres Of Hay	90	90	90	90	90
Avg. Bale Wt. (Lbs.)	1100	1500	1325	1400	1300
No. Of Bales	403	209	220	288	236
Land Costs/Acre	$26.90	$26.20	$27.45	$26.05	$27.25
Swathing/Acre	$4.23	$5.00	$4.23	$4.89	$4.90
Baling/Bale	$4.60	$5.00	$5.02	$5.25	$5.25
Stacking-Hauling/Acre	$8.85	$4.59	$4.83	$6.32	$5.18
Total Costs	$5,451.73	$4,265.93	$4,390.27	$6,117.45	$5,355.18
CRP Hay Value/T.	$25.00	$25.00	$35.00	$30.00	$28.00
Gross Return	$5,541.25	$3,918.75	$5,101.25	$6,048.00	$4,295.20
Net Return/A.	**$0.99**	**-$3.86**	**$7.90**	**-$0.77**	**-$11.78**

Table 7. Five-year and average per acre returns to land, labor and management for each enterprise/system on the CRP study.

	1992	1993	1994	1995	1996	5-Year Average
Net Return To System						
Cash Crop	-$14.42	-$ 4.65	-$18.78	-$57.06	$5.23	-$17.94
Oat-Sweetclover Rotation	-$14.42	-$12.68	$30.75	-$35.64	-$11.32	-$ 8.66
Grazing	$ 1.49	$ 5.82	-$ 9.62	-$21.39	-$ 6.62	-$ 6.07
Haying	$ 0.99	-$ 3.86	$ 7.90	-$ 0.77	-$11.78	-$ 1.50
Return To Land, Labor and Management						
Cash Crop	$12.48	$21.55	$ 8.67	-$31.01	$32.48	$ 8.83
Oat-Sweetclover Rotation	$12.48	$13.52	$58.20	-$ 9.59	$15.93	$18.11
Grazing	$34.05	$37.73	$23.54	$10.37	$26.39	$26.42
Haying	$27.89	$22.34	$35.35	$25.28	$15.47	$25.27

Callipyge Lamb: A Brief Summary[1]

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History of the *Callipyge* Gene. The origin of the heavy muscling phenotype is attributed to a Dorset ram called "Solid Gold" at a purebred and show lamb producer's farm, the Moffet Farms of Piedmont, Oklahoma. Solid Gold was born in 1983 and was recognized by his owner Andy Moffet for its extreme muscling. Solid Gold was used for breeding but not all of his lambs exhibited extreme heavy muscling characteristics. Public interest in this heavy muscling phenotype increased when Solid Gold's offspring and later generations began to win club lamb and carcass contests in the midwest United States. In 1993, the gene influencing the heavy muscling phenotype was identified with genetic markers by Dr. Noelle Cockett, Utah State University. The gene was named "*Callipyge*," which means beautiful buttocks to characterize its increased hind quarter muscularity. The gene is assumed to have been created as a result of a gene mutation because the *callipyge* gene is dominate and its phenotype is easily recognized.

The *callipyge* gene has been incorporated into several different breeds by crossbreeding with animals from the Moffet Farms Dorset flock (Table 1).

Table 1. Current sheep breeds crossbred with *callipyge* genotypes.

Meat Breeds	Wool Breeds	Prolific & Specialty Breeds
Dorset	Rambouillet	Romanov
Hampshire	Merino	Finnsheep
Suffolk	Polypay	Barbados
Southdown	Composites	Natives

Typical ewe breeds and tropical hair sheep may benefit from being crossed with a *callipyge* genotype because it should improve the degree of muscling in these lighter muscled breeds. Also, tenderness may not be decreased as much as with the more muscular breeds.

The *callipyge* gene, when introduced into other breeds, may have a negative correlated effect on other traits. Preliminary data indicates wool production may be decreased by the gene in Rambouillet sheep. Staple length was .3 inches shorter and grease fleece weight was 1.5 pounds lighter (12 versus 13.5 pounds) from *callipyge* animals compared with half-sib Rambouillets.

Evidence of another heavily muscled line of sheep is coming forth from Australia. It is not presently known if the Australian heavy muscling phenotype is caused by the *callipyge* gene or some other gene. We do know however, that the Australian sheep are not directly related to the "Solid Gold" ram.

Growth and Nutritional Requirements of *Callipyge* Lambs. The dietary intake of dry matter does not differ between lambs expressing the heavy muscle trait and normal lambs in most studies. However, *callipyge* lambs may consume slightly less on a metabolic body mass basis (weight$^{.75}$). There is no difference in digestibility of lamb rations. And, there is little or no difference in the growth rate of *callipyge* lambs compared to normal lambs. However, several studies have shown that *callipyge* lambs are more efficient in converting feed to weight gained; efficiency increasing 10 to 20%. Carcass studies indicate *callipyge* lambs have greater muscle accretion, dressing percentage, and retail yield. The increased retail yield is attributed to greater trimmed loin weights, rib eye area, and leg scores. Organ mass, as measured by weight, is decreased in the liver, small intestines, heart, and kidneys.

Energy Metabolism. A metabolic rate study observed no difference in fasting heat production between normal and *callipyge* lambs (48.9 and 50.7 kcal per kg$^{.75}$, respectively). However, *callipyge* lambs were observed to have a lower respiratory quotient (oxygen consumption divided by carbon dioxide production) than normal lambs when the lambs were shifted from a fasting state to an *ad libitum* state indicating *callipyge* lambs have a lower body fat synthesis.

Metabolizable Energy (ME). Callipyge lambs have a lower ME for maintenance than normal lambs (74.3 and 79.1 Kcal/kilogram$^{.75}$, respectively). The lower ME maintenance requirement of *callipyge* lambs may be explained by their lower organ mass and higher muscle mass because ME decreases as the viscera to muscle mass ratio decreases.

On full feed, normal lambs are more efficient in retaining ME, probalby because they have more, and fat is a more

[1]Updated and Modified Summary of Callipyge Lamb Symposium, Feb., 1996, Salt Lake City Utah

efficient tissue to maintain from an energetic standpoint.

Crude Protein Requirements. National Research Council (NRC) requirements are based on lean to fat ratio and frame size. For example, early weaned lambs have a greater protein requirement because they have a greater lean to fat ratio. Feeder lambs also have a greater requirement than finishing lambs. Moreover, pig research has shown that animals with greater muscle had a greater protein requirement. Several other factors influence actual crude protein requirements. 1)*Type of protein source.* A high rumen by-pass protein reduces the crude protein requirements are less than for a low by-pass protein. 2) *Level of feed or energy intake.* As the energy to protein ratio increases the protein requirement increases. 3) *Animal performance.* Animals with a faster rate of growth have a higher protein requirement.

There have been three studies conducted on *callipyge* lambs to determine their crude protein requirements. Texas Tech University concluded that 12% crude protein was adequate based on average daily gain and plasma nitrogen levels compared to an 18% crude protein diet. However, two studies from the University of Wyoming suggest the crude protein requirement to be higher. The first study concluded that 12% crude protein was not adequate for *callipyge* lambs compared to a 20% crude protein diet. The second study evaluated four levels of crude protein: 10, 13, 16 and 20%. Preliminary results indicate that 10% crude protein is not adequate for normal or *callipyge* lambs, 13% crude protein is adequate for normal lambs and a level higher that 13% is required for *callipyge* lambs. Further research on protein requirements is needed but it is likely that protein requirements for *callipyge* lambs are higher than for normal lambs.

In a second study at the University of Wyoming associated responses to the level of crude protein were observed. Increases in crude protein levels were associated with increases in loin eye area, leg score, and liver and kidney weights. However, subcutaneous fat over the rib eye was not affected by crude protein level.

Minerals and Vitamins. There has not been specific work to address this issue but no apparent deficiencies have been observed, so we assume they are adequate.

Inheritance of the *Callipyge* Gene. Dr. Noelle Cockett, Utah State University, in cooperation with Texas Tech University and the U.S. Sheep Experiment Station developed a genetic marker system to accurately classify the genotype for the *callipyge* carriers 97% of the time. This requires analysis of a DNA sample from the animal in question, as well as, both parents. The DNA test is accomplished by sending a 10 mL blood sample to a genetics laboratory, such as Dr. Cockett's. The lab test for costs approximately $7.00.

These abbreviations and definitions are used in the following discussion: C = *callipyge* genotype and/or phenotype; N = normal genotype and/or phenotype; $_M$ = the source of the gene was from the sire; $_F$ = the source of the gene was from the dam; Genotype = the genetic makeup of an individual or group; Phenotype = the detectable expression of the gene (i.e., with *callipyge* is the animal extremely muscular or not?). For example, C_MN_F indicates this individual received the *callipyge* gene from the sire and a normal gene from the dam.)

When heterozygous *callipyge* © rams are mated with homozygous normal (N) ewes the typical phenotypic ratio is 50% *callipyge* offspring and 50% normal (50% C_MN_F:50% N_MN_F) as illustrated:

	Parents			**Offspring**	
	Rams		Ewes	50%	50%
Genotype:	C_MN_F	X	N_MN_F	C_MN_F	N_MN_F
Phenotype:	*Callipyge*		Normal	*Callipyge*	Normal

When homozygous normal rams are mated to heterozygous *callipyge* ewes the normal expectation is 50% callipyge and 50% normal lambs; however, with 43 lambs resulting from this mating conducted at Texas Tech University, the U.S. Sheep Experiment Station, and Utah State University all offspring are normal lambs even though their genotypes are as follows:

	Parents			**Offspring**	
	Rams		Ewes	50%	50%
Genotype:	N_MN_F	X	C_MN_F	N_MC_F	N_MN_F
Phenotype:	Normal		*Callipyge*	Normal	Normal

If the *callipyge* gene shows simple dominance then when heterozygous *callipyge* rams are mated with heterozygous *callipyge* ewes the expected outcome would be:

	Parents			**Offspring**			
	Rams		Ewes	25%	25%	25%	25%
Genotype:	C_MN_F	X	C_MN_F	C_MC_F	C_MN_F	N_MC_F	N_MN_F
Phenotype:	*Callipyge*		*Callipyge*	*Callipyge*	*Callipyge*	*Callipyge*	Normal

However, the following actually occurred:

	Parents			Offspring			
	Rams		Ewes	25%	25%	25%	25%
Genotype:	C_MN_F	X	C_MN_F	C_MC_F	C_MN_F	N_MC_F	N_MN_F
Phenotype:	*Callipyge*		*Callipyge*	Normal	*Callipyge*	Normal	Normal
No. of lambs				19	23	15	18

The expected percentage of offspring lambs from a ram with a dominant *callipyge* gene would be 75% expressing the heavy muscle phenotype. However, only about 25% expressed heavy muscling. Dr. Cockett and her fellow researchers have determined that a recently discovered new form of genetic action is occurring with the *callipyge* gene. It is called ***polar overdominance*** which means that the phenotypic expression of a gene is dependent on parental origin. This appears to be the first documented case of polar overdominance in a farm animal. In the case of the *callipyge* gene, it appears that if offspring receive the *C* gene from the dam then the phenotypic expression of the *C* gene is blocked by polar overdominance and the lambs appear normal even if a second copy of the *C* gene is inherited from the sire.

Subsequent work has shown that the *C* gene inherited from the dam can be turned back on (or reactivated) when males with the inactivated *C* gene are mated to normal ewes. A series of matings were performed to substantiate maternal imprinting. When homozygous normal rams are mated to homozygous *callipyge* ewes (that are actually normal in phenotype) all the offspring have a normal phenotype.

	Parents			Offspring
	Rams		Ewes	100%
Genotype:	N_MN_F	X	C_MC_F	N_MC_F
Phenotype:	Normal		Normal	Normal

However, when homozygous *callipyge* rams (that are actually normal in phenotype) are mated to homozygous normal ewes all the offspring express the *callipyge* phenotype.

	Parents			Offspring
	Rams		Ewes	100%
Genotype:	C_MC_F	X	N_MN_F	C_MN_F
Phenotype:	Normal		Normal	*Callipyge*

Also, mating homozygous *callipyge* rams (that are actually normal in phenotype) to homozygous *callipyge* ewes (that are actually normal in phenotype) will produce all normal appearing offspring.

	Parents			Offspring
	Rams		Ewes	100%
Genotype:	C_MC_F	X	C_MC_F	C_MC_F
Phenotype:	Normal		Normal	Normal

Potential Breeding Systems. The complexity of the inheritance of the *callipyge* gene can confuse a producer. Therefore, different breeding systems based upon breeding objectives are presented. If a sheep producer's goal is to produce *callipyge* (C_MC_F) breeding rams that will produce all *callipyge* (C_MN_F) offspring when mated to normal (N_MN_F) ewes then the following breeding plan is recommended:

Phase I

CN	X	NN
Callipyge Males		Normal Females
½ C_MN_F	:	1/2N_MN_F
50% *Callipyge*	:	50% Normal

Save *Callipyge* males
and females.

Phase II

CN X CN
Callipyge Males *Callipyge* Females

¼ C_MC_F:1/4 C_MN_F : ¼ N_MC_F: ¼ N_MN_F
25% *Callipyge* : 75% Normal

Determine CC animals
from among Normals by
DNA testing.

Phase III

CC X CC
"Normal" Males "Normal" Females

All C_MC_F
100% "Normal"

In Phase II instead of DNA testing all the normal ewes, one could DNA test only the normal phenotype rams to identify homozygous *callipyge* (C_MC_F) individuals. Homozygous rams are then mated to any of the ewes from Phase II. Any normal offspring from these homozygous *callipyge* rams will be homozygous for the *callipyge* gene. For example, from matings with homozygous *callipyge* ewes the following outcome occurs:

	Parents			**Offspring**
	Rams		Ewes	100%
Genotype:	C_MC_F	X	C_MC_F	$\mathbf{C_MC_F}$
Phenotype:	Normal		Normal	Normal

Matings with heterozygous *callipyge* (C_MN_F or N_MC_F) ewes will result in the following:

	Parents			**Offspring**	
	Rams		Ewes	50%	50%
Genotype:	C_MC_F	X	C_MN_F	$\mathbf{C_MC_F}$	C_MN_F
Phenotype:	Normal		*Callipyge*	Normal	*Callipyge*

or

	Rams		Ewes	50%	50%
Genotype:	C_MC_F	X	N_MC_F	C_MN_F	$\mathbf{C_MC_F}$
Phenotype:	Normal		Normal	*Callipyge*	Normal

Once the phenotypically normal but genotypically homozygous *callipyge* animals are identified, the final step is Phase III, the interbreeding of homozygous *callipyge* animals. Then when the offspring of Phase III are mated to normal ewes (N_MN_F), all resulting offspring will exhibit the heavy muscled *callipyge* phenotype.

If the breeding objective is to produce *callipyge* (heavily muscled) lambs for market, there are two breeding options. The first option will produce only 50% heavy muscled lambs but does allow for selection of future heterozygous rams (C_MN_F) from within the same flock. The second option requires acquisition of homozygous rams (CC) on a continuing basis but produces 100% heavy muscled market lambs.

Option 1:

CN X NN
Callipyge Males Normal Females

½ $C_M N_F$: $1/2 N_M N_F$
50% *Callipyge* : 50% Normal

Select or buy *Callipyge* males. Sell all *Callipyge* females.

Option 2:

CC X NN
"Normal" Males Normal Females
All $C_M N_F$
100% *Callipyge*

Purchase CC males.
Sell all *callipyge* lambs.

Carcass Characteristics of *Callipyge* Lambs. There have been at least 11 studies on the carcass merit of *callipyge* lambs from 9 research institutions involving 256 normal and 209 *callipyge* lambs. In general, the carcass characteristics of *callipyge* lambs are more desirable than that of normal lambs. Dressing percent, on the average, of *callipyge* lambs is 54.8% compared to 50.9% of normal lambs, or 7.5% higher in *callipyge* lambs (ranging from a 5 to 9.3% higher).

Measures of fatness are decreased in *callipyge* lamb carcasses. Back fat thickness at the 12th rib is significantly lower; an average of 26.4% lower (ranging from 17% to 54% among studies) with fat thickness values of .23 inches in normal lambs to .17 inches in *callipyge* lambs. The subjective measures of shoulder seam fat quantities for *callipyge* lambs were, also significantly decreased. Potentially, the lower shoulder seam fat scores suggest that the value of lamb shoulders, which are currently difficult to merchandise, will be enhanced.

The muscle characteristics of the *callipyge* lamb carcass were improved. Rib eye area increases an average of 47% (ranging from 37% to 69%) with an average value of 2.26 square inches in normal lambs to 3.32 square inches in *callipyge* lambs. Also, the yield of closely trimmed leg, loin, rack and shoulder as a percent of live weight were increased in *callipyge* lambs by 11 to 16%.

Consumer Acceptance and Tenderness (Toughness) of *Callipyge* Lambs. Producers may benefit from increases in efficiency of production of lean meat and possible price premiums from packers for improved carcasses. Packers may benefit from increased yield of sub-primals. Retailers may see an increased consumer demand the for larger and leaner retail cuts from *callipyge* lamb carcasses.

However, all of these advantages are dependent upon consumer acceptance of *callipyge* lamb cuts. A consumer acceptance study with 600 panelists (Utah State) compared *callipyge* and normal loin chops. Seventy-four percent of panelists were likely or highly likely to purchase *callipyge* chops while only 27% of panelist were likely or highly likely to purchase normal chops.

Tenderness was determined qualitatively by panelists and quantitatively by Warner-Bratzler shear force values. For beef, a shear force greater than 5 kg is generally considered unacceptably tough. *Callipyge* lambs averaged 7 kg in shear force with values up to 11 kg while normal lambs averaged 4 kg. To determine the cause of this apparent toughness several post-harvest treatments to increase tenderness were evaluated, those treatments were: low voltage electrical stimulation, which prevents cold shortening, aging and calcium chloride injection. Aging *callipyge* lamb for 8, 15, or 22 days decreased shear force to below 5 kg, but not as low as for normal lambs aged for the same length of time. Electrical stimulation decreased the shear force of *callipyge* lambs. The combination of electrical stimulation, calcium chloride infusion and aging for 15 days reduced the shear force of *callipyge* lambs to 3.16 kg, which was very similar to the values for normal lamb muscles, which ranged from 2.5 to 3 kg. Sensory panel analysis indicated that electrical stimulation and calcium chloride injection of *callipyge* chops resulted in acceptable texture, flavor and juiciness scores but not as desirable as for normal chops.

Studies at Texas Tech, Oregon State and the University of Idaho have indicated that broiled or roasted muscles from the leg do not differ in tenderness between *callipyge* and normal lambs. Large differences in the tenderness of longissimus muscle (loin) were reported in these same studies.

In summary, more consumers are likely to purchase *callipyge* compared to normal chops (at least the first time). *Callipyge* loin chops tend to be less tender than chops from normal lambs but when treated to maximize tenderness, such as with electrical stimulation and calcium chloride infusion acceptable sensory properties can be obtained. The tenderness problem seems to be primarily localized in the loin and rack. The *callipyge* gene causes an increase in muscle mass due to hypertrophy (or increase in muscle fiber size), whereas the increased muscling of Texel sheep is primarily due to hyperplasia (or increase in muscle fiber number).

Methods For Tenderizing *Callipyge* Lamb. Currently, there are several investigations on improving the tenderness of *callipyge* loins. Such approaches include electrical stimulation, aging, freezing with aging, calcium salt injection, and hydrodyne processing. The acceptance of some of these procedures by the lamb packing industry for tenderizing the *callipyge* lambs is dependent on the added value of the *callipyge* carcass to offset the treatment cost. At present, preliminary research results are very favorable for aging, freezing with aging, and hydrodyne processing.

The hydrodyne is a new process involving water (hydro) and explosives (dyne). Simplifying the process, meat in retail packaged form is placed in semi-sealed chamber with a liquid, usually water, and an explosive material is ignited. This creates a hydro shock wave which ripples through the meat tissue tearing apart the muscle fibers (tenderization).

Results of the ongoing studies should be available in the spring of 1997.

Where Does the *Callipyge* Gene Belong? Basically, the *callipyge* gene is best suited for a terminal sire breeding program. This conclusion is derived from the biological effects associated with the *callipyge* gene. Consider that animals expressing the *callipyge* gene have an increase in lean tissue, as represented by increased yield grade, loin and hind leg weights and a significant decrease in fat, as represented in back fat thickness, shoulder seam fat scores, and carcass chemical analyses (Table 3).

Table 3. Carcass composition of 115 pound normal and *callipyge* lambs

Constituent	Normal	*Callipyge*	Percent Change
Water	59.9	61.6	2.8%
Protein	15.8	18.5	17.1%
Fat	21.2	16.8	-20.8%

A 21% decrease in carcass chemical fat and an increase of 17% in carcass protein clearly indicates that the fat to lean ratio in *callipyge* sheep is greatly altered. There is no reported study describing the effect of lower body fat in *callipyge* lambs on lamb reproduction. Generally, lower fat content (or energy reserve) is of great biological importance to female reproduction. Body fat serves as a major energy source during late pregnancy and peak lactation. Pregnant and lactating ewes begin break down protein (muscle) as they deplete there body fat reserves. This process causes the ewes to be more susceptible to pregnancy ketosis. Also, lambs born under these conditions are generally lighter and weaker at birth. Following birth, a ewe requires a significant increase in her dietary protein and energy for lactation; if these nutrients are not sufficiently available in her diet the ewe will begin to break down more muscle or cease to lactate. Prolific breeds of sheep (Polypay, Finn-crosses, Romanov, Booroola) expressing the *callipyge* phenotype will have less body fat and may not be suitable to raise multiple lambs. Therefore, pregnant and lactating *callipyge* ewes should be well cared for with additional levels of energy and protein in their diets. This is no reported negative effect of the *callipyge* gene on reproductive performance. Nor has there been any report of increased lambing problems (dystocia); most likely because the heavy muscle trait does express itself until about 4 to 6 weeks after birth. It should also be remembered that ewes exhibiting the *callipyge* phenotype should not be kept in the flock unless they are to be used in a breeding program to produce homozygous offspring. (The offspring from a *callipyge* ewe will not express the heavy muscled trait because of maternal imprinting.)

When the *callipyge* gene is used in a terminal sire program, there is much to be gained. As already discussed, most of the benefits of the *callipyge* gene are related to growth and muscling with an increase in feed efficiency and improvement in carcass merit. This has been demonstrated in Rambouillet, Columbia, Dorset and Suffolk sheep. A logical terminal breeding program appears to cross a meat type sire breed (Suffolk, Columbia, Hampshire) carrying at least one copy of the *callipyge* gene on an adapted prolific ewe breed (Polypay, Finncross, Romonov) that does not have the *callipyge* gene to produce lambs for slaughter.

The Economic Advantage of *Callipyge* Lamb. The economic value of *callipyge* is dependent on several factors. However, of foremost concern is consumer acceptability. The decreased tenderness of *callipyge* lambs, which appears to only be a significant problem in the loin and rack, is concerning. However, it should be remembered that we live in a culture that eats rice cakes; and perhaps we don't need to determine how to make *callipyge* lamb equal to normal lamb but only to increase its acceptability.

There are some obvious economic advantages of *callipyge* lamb. *Callipyge* lambs are 10 to 20% more efficient and gain lean muscle more rapidly. The total economic advantage to this biological difference is difficult to determine because live lambs are sold on a live weight basis, not on a compositional basis. However, it is rather simple to determine the economic advantage of a *callipyge* carcass. *Callipyge* lambs have 7.5% more carcass weight and 24% more muscle than normal lambs.

A. Consider the wholesale carcass value:

130 lbs live weight X .531 X 1.65 = $113.90
130 lbs live weight X .494 X 1.64 = $105.96
$7.94

That is a $7.94 advantage for the *callipyge* wholesale carcass.

B. Consider the value of the boxed lamb cuts (two 130 pound live lambs):

Cuts	Normal	*Callipyge*	C-N	Wholesale Price per lb.	Increased Value
Carcass weight	64.2	69.0			
Leg	12.5	15.3	2.8	X $2.05	$5.74
Sirloin	3.4	3.8	.4	X $2.45	$0.98
Loin	5.6	6.3	.7	X $3.15	$2.21
Rack	4.9	5.4	.5	X $4.18	$2.09
Shoulder	11	12	1.0	X $0.93	$0.93
					$11.95

The overall advantage is $11.95 for the *callipyge* boxed lamb cuts.

Further economic advantage can be recognized if value is placed on the increased loin eye area, the increased leg conformation, improved shoulder with less seam fat, and improved yield grade (1.6 vs. 2.4). Also, research has shown that *callipyge* lamb is a healthier product because of decreased cholesterol, lower total fat and especially saturated fat.

The callipyge gene also may enable U.S. lamb to compete against foreign lamb which is quickly improving in carcass quality. In order for the *callipyge* gene to be useful it must cost less than $7.94 per carcass and $11.94 for boxed lamb to tenderize the loin and the rack cuts.

Summary

1. *Callipyge* lambs do not differ from Normal lambs in growth rate, they exhibit 10-20% more desirable feed efficiency.
2. *Callipyge* lambs may have slightly greater dietary crude protein requirements.
3. The inheritance of the *Callipyge* trait appears to be affected by maternal imprinting. If offspring receive the *Callipyge* gene from the mother they are Normal in phenotype no matter what gene comes from the sire. Therefore, homozygous *Callipyge* animals (which received *Callipyge* genes from both their sire and dam) are Normal in phenotype.
4. It is possible to develop a flock of homozygous *Callipyge* animals that are all Normal in phenotype. Rams from this flock when mated to homozygous Normal ewes will produce 100% *Callipyge* phenotype lambs.
5. *Callipyge* lambs excel in dressing percentage (7.5%) ribeye area (~ 50%), leg conformation score, have less fat thickness (~ 25%), greater yield of closely trimmed retail cuts and less seam fat.
6. *Callipyge* lamb cuts appear to have greater consumer acceptance at the retail counter (at least the first time) because of larger size, less external and seam fat.
7. *Callipyge* loin and rack cuts are generally tougher than cuts from Normal lambs but little difference has been found in leg and shoulder cuts.
8. Post-harvest treatments such as; aging, electrical stimulation, calcium chloride infusion and hydrodyne processing are able to bring the tenderness of *Callipyge* lamb chops to acceptable levels.

Final conclusion, *callipyge* lambs offer the industry and consumers many advantages, therefore, adequate resources need to be applied to solve the tenderness problem.

Composite Trait Selection to Improve Lamb Production[1]

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Introduction

The single most important economic trait in American commercial sheep production is the litter weight weaned per ewe exposed at breeding. This implies that the production unit of a commercial sheep operation is the ewe. The economic products produced by the ewe are wool and lamb. The loss of the Wool Incentive Program combined with lower wool prices in recent years have increased the economic importance of the total litter weight weaned per ewe. Current farm prices (August 2, 1996, ASI Market News) for wool ($3.52 per kg, clean weight at 22 micron) and lamb (US$1.96/kg, 27 - 41 kg feeder lamb) indicates that gross income from lamb exceeds that from wool by ten fold. Consider a western range commercial sheep operation with wool characteristics of an average fleece weight of 3.9 kg (8.5 lbs), clean yield of 55%, and 22 micron fiber (62s) and an average 120 d old lamb weaned at 38.6 kg (85 lb) for 100 percent weaned lamb crop (one lamb per ewe). The gross return from wool is US$7.55 compared to US$75.66 from rearing a single lamb. Hence, genetically increasing marketable litter weight per ewe is one of the most important contributions genetics can make to the economy of the sheep industry.

Some genetic increases in litter weight weaned can be made quickly through crossbreeding with prolific breeds. However, introduction of new breeds, often exotic, can result in unadapted genotypes with or without other desirable characteristics. Also, after crossbreeding has been throughly exploited, the only recourse for continued genetic progress is via selection for genetically superior individuals within breeds or crosses. It is important, therefore, to determine the relative effectiveness of alternative selection procedures for improving litter weight weaned.

The trait, litter weight weaned, is a composite trait which means that the expression of this trait is dependent upon several component traits. Litter weight weaned is a combination of several different aspects of ewe reproduction (fertility, and litter size), ewe viability and offspring growth rate (mothering ability, milking performance, lamb survival, lamb growth rate). Thus, it is a convenient biological and economic measure of ewe productivity (Martin and Smith, 1980; Ercanbrack and Knight, 1985).

Long term selection for a single composite trait should, in theory, improve each individual trait. Traits within a composite trait are not expected to improve at the same rate because they generally differ in genetic responses to selection. However, the net effect of selecting for a composite trait is a balanced biological system. Whereas, selection for an individual trait may not result in a balanced biological system. For example, selection for ovulation rate in sheep may be positive but gains in ovulation rate can be offset by decreased embryo survival (Bradford, 1985). Similarly, selection for increased litter size may not be accompanied with increased milking performance and lamb growth rate. Direct selection for litter weight weaned in mice was three times as effective as selection for litter size for increasing litter weight weaned (Luxford and Beilharz, 1990). Results of long term selection for weaning weight in Targhee sheep were decreases in lamb survival to weaning, ewe fertility, and litter weight weaned (Lasslo et al., 1985). From this last study, it is obvious that single trait selection for growth rate to weaning can improve weaning weight but it does not increase and may decrease total lamb production per ewe. Thus, litter weight weaned per ewe exposed is the most appropriate composite trait to be used in selection for increasing total lamb production.

Breeders should also be mindful that genetic change in animal production results in biological change of the animal, often requiring a corresponding change in nutritional and management inputs. The upper limits for genetic improvement of a production system are determined by its nutritional and management constraints. In a selection study to increase weaning weight in Targhee sheep in two different environments (range vs irrigated pasture-feedlot) genetic improvement was significantly greater in the better environment (Lasslo et al., 1985).

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[1]Modified from presentation at the National Sheep Genetics Symposium, Sept., 1996, Columbus, OH

In relation to litter weight weaned, consider the extensive production situations identified by Bradford (1985). An extensive production system may have limited forage availability with nutritional supplements being scarce or uneconomic and limited labor at lambing. Under this extensive system, the goal for increasing litter weight weaned would be restricted to production of only one lamb per ewe with satisfactory growth. However, under an improved extensive production system with better forage availability, especially in the early spring and summer, the litter weight weaned may be greatly improved with multiple births, increased milk production, and improved lamb growth. Thus, it is important for the sheep breeder to recognize the environmental potentials and limitations for genetic improvement. Selection response for a composite trait such as litter weight weaned under any production system should result in a well adapted and biologically balanced ewe because she has been selected for her genetic potential to raise a lamb to weaning.

Selection Response for Litter Weight Weaned

The most significant selection study for litter weight weaned has been conducted at the U.S. Sheep Experiment Station by Drs. Keith Ercanbrack and Arlin Knight since 1976. Selection occurred under western range conditions which included shed-lambing and grazing of mountain summer range amid coniferous forests at elevations of 2,000 to 2,900 meters. Selection lines were established in four breeds of sheep (Rambouillet, Targhee, Columbia, and Polypay). Ewes were selected on their lifetime average of litter weight weaned and rams were selected on the basis of their dam's record. Selection response was positive during the 12 years (1976 - 1988) of selection for litter weight weaned. Non-selected random bred Rambouillet and Targhee control lines were maintained during the study; the average of these two lines was used for estimating environmental trends. Tables 1 and 2 indicate the phenotypic and genetic responses for reproduction and body weight, respectively, for the selected and randomly bred control lines.

The phenotypic trends (Table 1 and Figure 1) over years were positive for reproductive traits and body weight. Modest increases in phenotypic trends in the control lines indicates there were improvements in management and(or) environment over the time period. Genetic improvement (Table 2) was generally positive for all traits. Genetic improvement for litter weight weaned averaged .69 kg per year. For a flock of 100 ewes this represents an annual increase in marketable lamb of 69 kg; or US$135.24 increase in gross sales. Over a 12 year period, selection for litter weight weaned resulted in a genetic improvement of 8.28 kg/ewe; or increased the gross return per ewe by US$16.23 based on today's current prices.

Table 1. Linear regression coefficients (annual rates of phenotypic improvement) for reproductive traits and body weight

Breed/Line	Fertility, %	Prolificacy, %	Born live, %	Lambs weaned, %	Ewe viability[a], %	Body weight, kg	Net rate[b], %
Rambouillet	.84	2.54	.00	.36	.27	.82	2.77
Targhee	1.49	1.84	.65	.53	.15	.51	3.68
Columbia	1.81	1.84	.41	1.17	.25	.82	4.08
Polypay	.46	1.16	.00	.45	.20	1.03	2.19
Control[d]	.92	.41	.26	.18	.07	.27	1.37

[a] Ewe viability = percent ewes alive at lambing per ewe into breeding
[b] Net rate = net reproductive rate, lambs weaned per ewes into breeding
[c] Litter weight weaned = total litter weight of lambs weaned (120 d) per ewe into breeding
[d] Control is average of non-selected randomly bred Rambouillet and Targhee lines
Data from Ercanbrack and Knight, unpublished.

Breed differences in response to selection for litter weight weaned were observed. Improvements for reproductive traits were less in the Polypay breed when compared to the other breeds despite its outstanding superior means for litter weight. The rate of response to selection was negligible during the early years of the selection study but increased after 1984 (Figure 1). The Polypay breed is a newly introduced breed; and in 1976 several F2 and F3 generation ewes were still present in the flock. The delayed response to selection for litter weight weaned in early generations was examined by Snowder et al. (1996) who reported that at least three generations were necessary to overcome the loss of reproductive performance due to decreased heterosis and recombination loss.

Table 2. Annual genetic improvement[a] among lines selected for litter weight weaned.

Breed/Line	Fertility, %	Prolificacy, %	Born live, %	Lambs weaned, %	Ewe viability[b], %	Body weight, kg	Net rate[c], %
Rambouillet	.00	2.14	-.29	.18	.20	.55	1.40
Targhee	.57	1.43	.39	.35	.08	.24	2.31
Columbia	.89	1.43	.15	.99	.18	.56	2.71
Polypay	-.46	.75	-.26	.27	.13	.77	.82

[a] Genetic improvement estimated by the difference in regression coefficients between selected and control lines.
[b] Ewe viability = percent ewes alive at lambing per ewe into breeding
[c] Net rate = net reproductive rate, lambs weaned per ewes into breeding
[d] Litter weight weaned = total litter weight of lambs weaned (120 d) per ewe into breeding
Data from Ercanbrack and Knight, unpublished.

The selection response for litter weight weaned at the U.S. Sheep Experiment Station was positive and significant. However, breed specific heritability estimates for litter weight weaned per ewe exposed are extremely low (Rambouillet, .07; Targhee, .06; Columbia, .00; and Polypay, .02; Sakul, unpublished data). Low heritability estimates for a complex trait such as litter weight weaned are expected because the trait is subjected to all the environmental influences from breeding to weaning. The overall repeatability for litter weight weaned was .06 which also suggests strong environmental influences on this trait. The genetic improvement observed by the flocks at the U.S. Sheep Experiment Station does indicate that although the heritability is low, the trait does respond to selection. The average estimated breeding values for litter weight weaned more than doubled after 12 years of selection at the U.S. Sheep Experiment Station (Dr. Hakan Sakul, unpublished data).

The reason for the positive selection response for this low heritable trait can be explained by examining the factors influencing selection response. Selection response is affected by three main factors: heritability, selection differential and phenotypic variation. The maximum rate of response to selection occurs when all three of these factors are at their maximum value for that trait. Response to selection for low heritable traits can be significant if the trait has a large phenotypic variation and(or) the selection differential is large. The phenotypic variation for litter weight weaned is extremely large. The coefficient of variation is a statistical value (standard deviation divided by the mean) used to compare variation among different traits. The coefficient of variation for litter weight weaned at the U.S. Sheep Experiment Station is approximately 75%. The coefficients of variation for fertility, prolificacy, number of lambs weaned, body weight and grease fleece weight in the same population are much lower (35, 31, 60, 12, and 17 %, respectively). Consequently, the selection response can be significant for litter weight weaned.

Because litter weight weaned is a sex-limited trait with a low heritability, the accuracy of selection can be improved by considering more information on breeding individuals. This can include records on relatives and multiple observations on a single individual. Martin and Smith (1980) reported that by adding records on the dam and paternal half sibs to those of the ewe increases the rate of genetic response by 10 to 50% for litter weight in sheep. Future improvements to the genetic analyses used in the National Sheep Improvement Program may take advantage of this approach. Another approach to enhance selection response for low heritable traits is to increase the selection differential by maximizing the number of offspring from high performing ewes with multiple ovulation and embryo transfer in a nucleus breeding scheme (Teepker and Smith, 1990).

Contribution of Components of Reproduction to Litter Weight Weaned

An approximation of the relative contributions of the components (Turner and Young, 1969) of reproduction to genetic change in litter weight weaned by Ercanbrack and Knight (unpublished) indicated that 37% of the genetic improvement was attributed to prolificacy, 27% to percentage of lambs weaned, 17% to lamb weaning weight, 12% to fertility, and 7% to ewe viability. Improvements in these traits occurred simultaneously during selection for litter weight weaned, both phenotypically (Table 1) and genetically (Table 2).

These approximations of component relative contributions have also been confirmed by other studies of the biological differences between the Targhee line selected for litter weight weaned and the Targhee non-selected randomly bred control line at the U.S. Sheep Experiment Station. Selection increased litter weight weaned through at least three biological events: 1) increased ovulation rate and (Stellflug et al., 1994), 2) heavier lambs within parity group (Head et al., 1995), and 3) increased pregnancy rate in ewe lambs (Westman, 1993).

Biological Changes in Sheep Selected for Litter Weight Weaned

Comparative studies of the Targhee line selected for litter weight weaned and the random bred control line have identified significant biological differences between the lines (Head et al., 1995, 1996a, 1996b). Ewe lamb fertility is 40% (21 percentage units) higher (Hatfield and Stellflug, unpublished data). When Targhee sheep were selected only for litter size there was no improvement in age of puberty (Li et al., 1992). Daily milk production increased 13% in the selected line (Head et al., 1995). Selection studies to increase individual lamb weaning weights in Merino sheep have reported increases in milk production by 10% (Pattie and Trimmer, 1964) and 12 % (Hinch et al., 1989).

Growth hormone concentrations in lactating ewes from the selected lines were higher than control ewes (Head et al., 1996a). The major functions of growth hormone are increased lipolysis, diabetogenesis, protein accretion, bone growth, gluconeogenesis, mammogenesis and galatopoiesis (Bauman and McCrutcheon, 1986). Therefore, the higher growth hormone concentration in the selected line infers the potential presence of other biological differences yet to be identified.

Twin lambs from selected ewes were heavier at weaning, consumed more milk and had higher levels of dry matter intake (forage) than twin lambs from control ewes (Head et al., 1995). However, post weaning performance for gain, feed intake and carcass characteristics was similar among lambs from selected and control lines (Head et al., 1996b). The results from these studies suggests that preweaning effects are of greater significance in the selected line than the control.

Wool production (grease fleece weight and wool grade) did not differ between selected and control lines after 12 years of selection for litter weight weaned (Ercanbrack and Knight, unpublished data).

Body Weight Increases with Selection of Litter Weight Weaned

Body weight increased phenotypically and genetically in all breeds selected for litter weight weaned (Table 1 and 2). This positive correlated response suggests that selection favored larger ewes more adapted to the nutritional environment under which they were selected. Similar observations pertaining to the positive relationship between litter weight weaned and body weight have been reported in mice (Luxford and Bueilharz, 1990). Selected mature ewes were heavier at breeding and during lactation than control ewes. This was also observed for the body weights of selected ewe lambs which were 4.5 kg or 14% heavier at breeding than control ewe lambs. This increase in body weight does not appear to be related to forage intake expressed as a percent of body weight because this did not differ between selected and control lines (Head et., 1995).

Implications

Total lamb production per ewe can be increased by selection for litter weight weaned. Selection response to litter weight weaned can be significant. Responses in correlated traits (fertility, prolificacy, milk production, lamb survival and growth) indicate that a balanced biological system results from selection. For this reason, breeders are advised to select for the composite trait, litter weight weaned, over other single traits. Potential limitations to selection response need to be recognized because increases in ewe body size, milk production and lamb forage intake require increased nutritional inputs.

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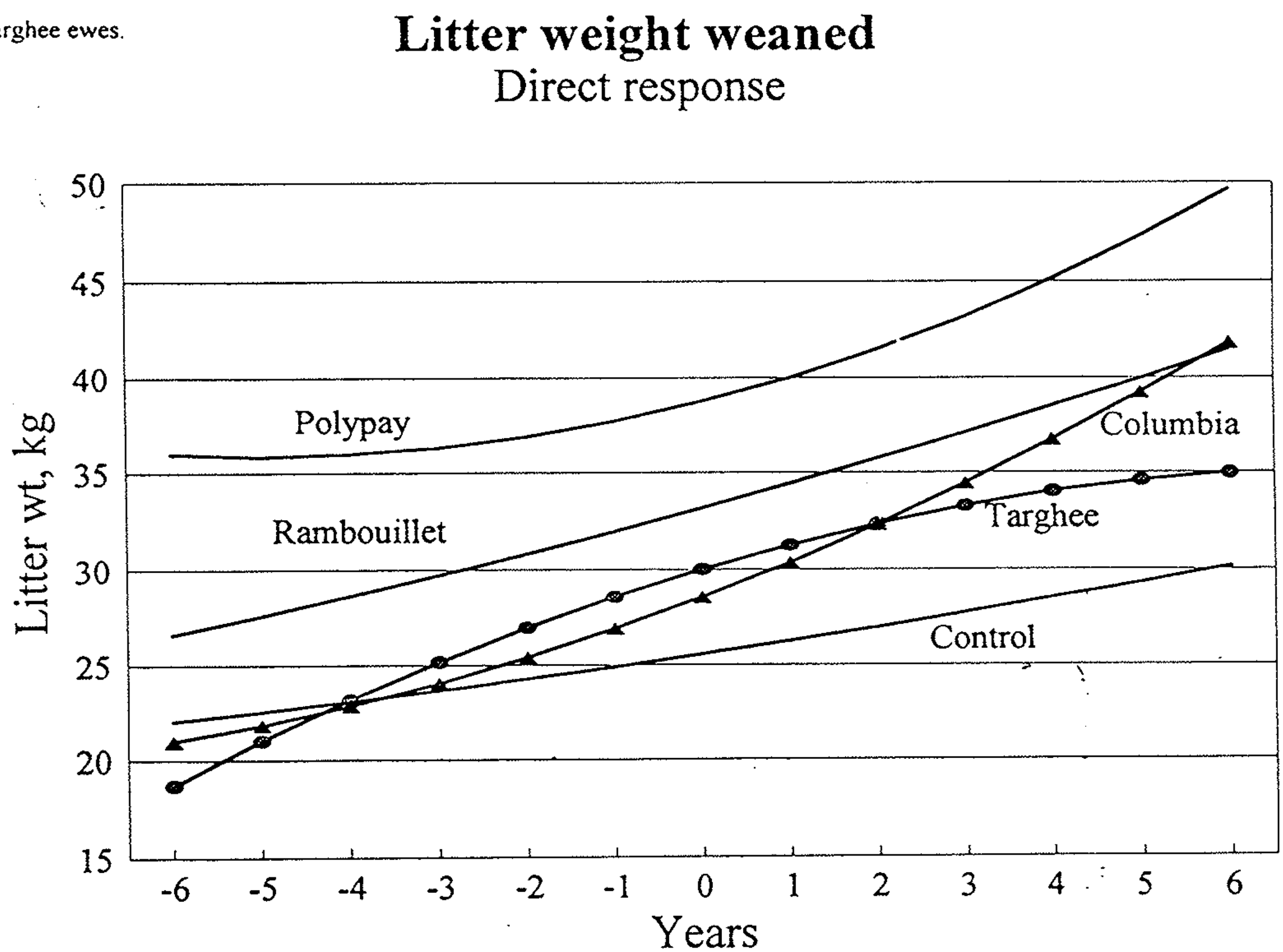
Figure 1. Breed direct response to selection for litter weight weaned expressed as a deviation from the median year (1976 - 1988). Control populations were non-selected randomly bred Rambouillet and Targhee ewes.



SECTION III
MANAGEMENT SECTION

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SHEARING MANAGEMENT

Animal production systems are in a constant state of flux. Producers are always making decisions that eventually effect their profitability. Some decisions such as breed selection and sire selection are of a long term nature. Normal management decisions may have long term effects but in general are thought of as only effecting profitability on an annual basis. Time of shearing is one of those management choices that is made on an annual basis and really only effects profitability in one given year. Producers have already made a decision when they wish to lamb and this decision may effect if they decide to shear prior to or after parturition. The potential hazard of environmental and climatic change are essential in determining time of shearing.

The following is a list of considerations for producers when deciding which shearing date might fit them best.

ADVANTAGES

1. Reduced space requirements based on removing the annual wool clip or the provision of needed space for the baby lambs which are soon to arrive. If you shear after lambing you must provide space for the ewe, the wool and the lambs.

2. Warmer and drier lambing facilities are very positive advantages to consider when making shearing time decisions. Wool has a very absorbent characteristic which tends to keep more moisture in the lambing facility when the ewes are in full fleece. Wool is also an excellent insulator which reduces the effect of body heat when the ewes are housed inside in full fleece.

3. It is a well known fact that newborn lambs will find the teat more easily when the udder is bare. If your system requires shearing after lambing then you should shear away all wool from the udder to assist the newborn lamb in finding the teat. You may do this individually as the ewes lamb providing that you are usually present at lambing. If not you should crutch the whole brood ewe flock just prior to the first lamb being born. Crutching does increase variable costs.

4. More ewes will tend to lamb indoors when you allow them to go outside during the day for feeding purposes if they are shorn as opposed to not. Producers may experience a reduced problem with chilled udders when the ewes are shorn and fed outside than when they are crutched and fed outside. The shorn ewes tend to come back into the barn after eating while ewes in full fleece tend to lay on the cold ground more often.

5. A much cleaner wool clip is a major advantage to shearing prior to the onset of lambing. Most wool contamination from the lambing process comes from bedding techniques, lambing fluids, and normal body fluids associated with parturition.

6. Many times a wool break occurs because of the lambing process. It occurs because of normal fevers and stress associated with lambing. If it does occur it is better to have the break on the outside of the fleece than on the inside.

7. Paint brands will remain more legible when the ewe is branded and in short fleece as opposed to the long staple. Shearing after lambing may set up the incidence of having to re-brand the ewes and again increasing variable costs.

8. A major advantage of shearing prior to lambing is that the producer has an opportunity to evaluate and pick up body condition if the ewes are found to be too thin. The producer may find that only certain individuals are too thin possibly because of age differences or the presence of internal parasites. To use this management tool effectively it would suggest that shearing should occur about thirty days prior to the onset of lambing.

9. The most effective time to treat for external parasites is when the ewe is freshly shorn. The elimination of both internal and external parasites prior to lambing is just one less stress the ewe must contend with at this very important time.

After considering the advantages of shearing prior to lambing producers should not fail to equally weigh the disadvantages which may not be as numerous but may be the limiting factors for his operation.

DISADVANTAGES

1. If the sheep producer has selected a very severe or variable climatic time as his best time to lamb and availability of quality housing is limited the sheep producer may chose to shear after lambing. In a future year the producer might adjust his lambing time to better mesh lambing time with the desire to shear in advance of lambing.

2. Taking the wool off the ewes body when it is cold or inclement increases her energy requirement. This clearly says that a shorn ewe requires more feed during bad weather than a ewe with her wool coat on.

After you weigh the pros and cons of shearing time it would appear that most but not all sheep operations would profit by selecting a shearing date prior to the onset of lambing. The producer that does select to shear prior to lambing is faced with some additional management considerations.

Many producers perform a wide array of management tasks approximately 25-35 days prior to the start of lambing. Shearing, treating for internal and external parasites, vaccinating for enterotoxemia, and trimming hooves are all routine management tasks that fit well together. Actual shearing date selection, lining up quality shearers, providing dry, clean housing, and climatic conditions of the date selected are all factors that will influence success of accomplishing actual shearing on the date selected.

Management associated with harvesting of the sheep producers second crop is a very important factor in determining ultimate profitability of the total sheep enterprise.

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. 1 pound grain/day two weeks 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 1/2 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 10 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