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Forage Production and Utilization Systems for Cow-calf Beef Production

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FORAGE PRODUCTION AND UTILIZATION SYSTEMS FOR COW-CALF BEEF PRODUCTION

by

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FORAGE PRODUCTION AND UTILIZATION SYSTEMS FOR GROWING COW-CALF BEEF PRODUCTION

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

One of the natural resources which plays an important role in the economy of South Dakota is its grasslands. Lewis et al. (15), in 1957, reported that "Nearly 60 percent of the total land area in South Dakota state is native range and 10% is seeded to tame grass and alfalfa."

In 1980, rangelands were reported to constitute 358 million hectares or 39.2 percent of the total land area in the 50 states and encompass 55.8 percent of the land area of the 17 western states which makes up 99 percent of the rangeland in the 48 contiguous states (7).

Rangelands have many products and uses. The majority of the world's meat, milk, wool, hide and other animal products are obtained indirectly from rangelands. They provide forage and habitat for wildlife, and are a natural source of germplasm that could be used in future plant breeding programs.

The base of the grazing farm lands in the Great Plains is the native grasses. Native grass yields are relatively low and overgrazing tends to make them even lower. Also the crude protein content of the native grasses rapidly decline during the grazing period (7, 3).

Ellison (6), in his discussion of rangelands, stated that grazing causes secondary succession because man and his management played no role in the original vegetation development, and he concluded:

1) Forage production in general is enhanced by grazing

2) Plants adapt to drought conditions by reducing their leaf surface area to grazing
3) Forage seeds are usually carried and dispersed by grazing animals
4) Fertility of range is mostly due to decomposition of existing organic matter and manure from animals

Efficient use of the nation's agricultural resources in grasslands requires not only a knowledge of forage production and the response of forage to defoliation, but also requires a knowledge of the quantity consumed by animals and the extent to which the forage provides the nutritional requirements of the animals.

Interseeding has become an acceptable alternative method for establishing pasture type alfalfa. Interseeding is the seeding of a legume and/or a more productive grass into permanent grassland with minimum tillage of existing sod. Experimental pastures interseeded with adapted species have significantly increased forage production in South Dakota (7). The benefits of interseeding are as follows:

1) Interseeding with species that produce forage when pasture production is low for the established species extends the pasture season
2) Total animal gain per hectare is increased by increasing the carrying capacity of interseeded pastures
3) Interseeding with forage species which are high in crude protein improves the forage quality of the whole pasture

The principle objective of this study was to evaluate the effect of various tame pastures combined with native and native interseeded range on cow-calf production and to determine the best pasture system for animal production in northcentral South Dakota.

LITERATURE REVIEW

The basics of good farming apply equally to range as to row crops. Production can usually be maintained when good management is practiced. Range under normal South Dakota conditions recovers rapidly from drought; however, range does not recover very quickly from overgrazing. Overgrazing can usually be prevented by knowing and adhering to the carrying capacity. Grazing systems are used as a management tool by the livestock producer to utilize and produce forage and livestock efficiently.

Bommer (2) has stated that rangeland is the terminology applied to grazing land derived from extensively used natural vegetation which is of low productivity in comparison to pasture or other forage crops.

A grazing system is "a specialization of grazing management which defines systematically recurring periods of grazing," Heady, H. F. (9).

The Great Plains spans the area from Canada to Mexico and from the Rocky Mountains to Wisconsin and offers a unique ecosystem to study forage production and utilization systems for growing and finishing beef cattle. The USDA has subdivided the Great Plains in four different categories of ecosystems (8). The vegetation of the four ecosystems are described as follows:

1) Plains grasslands: This consists of warm season grasses, western wheatgrass (Agropyron smithii), green needlegrass (Stipa viridula and shrub-like junipers (Juniperus spp.).
2) True prairie: The vegetation is mainly bluestem (Andropogon spp.), indiangrass (Sorghastrum avenoceum) and switchgrass (Panicum

virgatum).

3) Shinnary: Composed of broad-leaved shrubs, little bluestem (Schizachyrium scoparium) and sideoats grama (Bouteloua curtipendula).

4) Texas savanna: This ecosystem carries shrubs and bluestem. The four ecosystems described above cover about 38.4 percent of all the grass and shrub land of the United States (8).

The native range at the research site in this study, has the following composition, Fransen (7);

a) Kentucky bluegrass (Poa pratensis)

b) Needle and thread (Stipa comata)

c) Western wheatgrass (Agropyron smithii)

d) Bluestem (Andropogon spp.)

e) Switchgrass (Panicum virgatum)

According to Kuchler (11) this composition belongs to the Plains grasslands ecosystem which covers a major part of northwestern South Dakota.

Native grasslands in South Dakota are extremely variable and have steadily declined in condition (16). Pasture techniques are currently available to modify vegetation composition and productivity to bring about higher yields. Development of pasture systems that increase forage production is of a major importance in South Dakota (12, 18, 25).

Fransen (7) found that tame pastures and interseeded native range produced more gain per hectare than native range. The average

daily gain of the cattle dropped severely at the end of the season in native and native-interseeded range. However, the tame pastures required substantial inputs in terms of fertilizer nitrogen.

The purpose of this study was to find a combination of tame and native or tame and native-interseeded pastures that would maintain the average daily gain of the cattle. A second objective was to try to reduce the fertilizer inputs on tame pastures by seeding the tame pastures with alfalfa.

South Dakota studies over a 3-year period with native and native interseeded range were encouraging. Vigil (26) pointed out that in native interseeded range, animal gain and carrying capacity increased by 51 and 60 percent, respectively, over non-interseeded ranges. In South Dakota, it is an acceptable practice to rennovate pasture lands through interseeding. This method does not require prior seedbed preparation (10).

Native range in South Dakota has produced an average of 2.16 animal unit months (AUM) of grazing per hectare, while a mixture of smooth bromegrass-intermediate wheatgrass and "Teton" alfalfa produced 3.25 AUM of grazing; and a series of four seasonal tame grass pastures produced a significant increase in animal production over native range (13). Shane (23), after reviewing several pasture systems, concluded that the most economically feasible system was native range followed by short and full season tame series.

In a study reported by Smoliak (24), grazing crested wheatgrass followed by native pastures and Russian wildrye resulted in a two- to

three-fold improvement in forage production. Smoliak (24) reported a 55-60% increase in beef production from yearling steers grazed on crested wheatgrass, native range-Russian wildrye, rotation over native range alone. Campbell (4), pointed out that the use of crested wheatgrass pastures for early season grazing combined with the use of native grass later in the season resulted in very substantial increases in grazing capacity of the native grass pasture. Sarvis (22), reported that a good practice in managing crested wheatgrass pastures in the Northern Plains has been to graze them early in the season then move the cattle to native grass pastures sometime between mid-June and early July.

Whitman et al. (27), stated that the total production of protein per acre is a product of the percent crude protein of grasses times the dry-weight production. He pointed out that crested wheatgrass and Russian wildrye produced more total protein per acre when harvested frequently as a pasture than when harvested once each season as hay. Investigators from Wyoming reported two- to-three fold increase in cattle liveweight when grazed on seeded pastures compared to native range (14).

A study conducted by Rauji (20) showed that percent crude protein of crested wheatgrass varied with the years and date of harvest, i.e. the later the harvest date, the lower the percent crude protein content of crested wheatgrass. Whitman, et al. (27), reported that higher crude protein was produced by crested wheatgrass growing in association with alfalfa than crested wheatgrass alone. The results

were consistent over a period of seven years 'and an increase of 57 percent in animal gains for crested-alfalfa per acre was reported.

The addition of a legume in a pasture increases dry matter yield, crude protein content of the herbage and livestock gains. Campbell (4) in 1963, concluded that Russian wildrye produced more consistent yearly yield and maintained better stands than native range. One pound of alfalfa, interseeded with crested wheatgrass and Russian wildrye, resulted in greater yield of dry matter, higher crude protein percentage and higher carrying capacity.

Whitman et al. (27), in 1963 reported that the presence of alfalfa in a mixture with grasses contributed substantially to increasing forage quality and total per-acre production of crude protein. The crude protein of Russian wildrye and crested wheatgrass with no alfalfa was 16.3% and 15.5% respectively, and with alfalfa was 19.2% and 17.9%, respectively. Pasture clipping yields of a given grass with alfalfa were consistently higher than the yield of the specific grass alone. The average yield of a Russian wildrye-alfalfa mixture, the highest producing mixture, was 38.9% greater than the production of Russian wildrye alone.

There are other economically viable systems which increase dry matter production, crude protein content and livestock gains. Anthony and Harris (1), observed differences in cattle weight gain from two different ranges. Livestock gained an average 94 and 252 kg/ha when grazed on smooth bromegrass and brome-alfalfa pastures, respectively. Conversely, animals grazed on pastures with crested

wheatgrass gained 100 kg/ha compared to 245 kg/ha when alfalfa was grown with wheatgrass. In an Australia study, a linear relationship was formed between average daily gain of steers and the amount of alfalfa present in the pasture (17).

Interseeded pastures yield more forage with a higher percentage of protein than grass alone. It is therefore, desirable to work with interseeded systems in order to improve both the quality and the quantity of the native ranges. Some investigators have studied as many as three different combinations of pastures and ranges within one year in order to improve beef production. Some of these combinations are:
a) Native range, crested wheatgrass and russian wildrye (23, 24, 27)
b) Native, interseeded and tame grasses (7, 13)

In this study, tame pastures were combined with both native and native-interseeded pastures with the tame pastures being utilized at the beginning of the grazing season in all systems and at the end of the grazing season with several systems. A comparison was also conducted between tame pastures plus fertilizer nitrogen and tame pastures seeded with alfalfa. Animal and forage production were used to evaluate the systems.

MATERIALS AND METHODS

This study was conducted at the Pasture Research Center located near Norbeck, South Dakota. The ranch has class I, III and IV type soils with predominantly a Williams type. A four-year grazing study was conducted to evaluate the six pasture systms listed in Table 1. The characteristics of the tame grasses used in the study are as follows:

1. Crested wheatgrass (Agropyron cristatum) is a cool-season perennial bunchgrass with a deep fibrous root system. It is very drought tolerant, and is recommended throughout South Dakota for spring and fall season pasture. It is highly palatable and nutritious, and Alfalfa can be interseeded with it to enhance forage production (5).
2. Russian wildrye (Elymus junceus) is another cool-season grass recommended for the spring and fall seasons. This grass maintains a high level of protein during the grazing season and provides green forage for a longer time. It is nutritious, palatable, high yielding, and drought resistant (5).
3. Smooth bromegrass (Bromus inermis) is a leafy, sod-forming, cool season, widely adapted perennial grass. It is recommended for use with alfalfa for hay or pasture. Smooth bromegrass produces excellent yields of palatable high quality forage (2-3 tons per acre) (5). In early stages of growth, crude protein of grass-alfalfa mixtures may range from 12-20 percent. Protein content decreases rapidly with maturity.

The six pasture systems are listed in Appendix 22 along with the

Table 1. Forage systems for cow-calf production at Norbeck, SD 1980-1983.

System Number	Approximate Grazing Period*				
	April 25-June 1 (36 days)	June 1-June 30 (30 days)	July 1-August 31 (61 days)	September 1-September 30 (30 days)	October 1-November 1 (32 days)
1	Crested wheatgrass	Native	Native	Native	Native
2	Crested wheatgrass	Native-interseeded	Native-interseeded	Native-interseeded	Native-interseeded
3	Russian wildrye	Native	Native	Russian wildrye	Russian wildrye
4	Russian wildrye	Native-interseeded	Native-interseeded	Russian wildrye	Russian wildrye
5	Crested-alfalfa	Brome-alfalfa	Native	Native	Native
6	Crested-alfalfa	Brome-alfalfa	Native-interseeded	Native-interseeded	Native-interseeded

*Pasture components to be used in each system; the order of use of these components was flexible and depend on yearly climatic conditions. Sudangrass was used to replace pastures in the later grazing periods when the pastures failed to produce enough forage.

Crested wheatgrass (Agropyron cristatum (Fisch. ex Link) Schult.)
Russian wildrye (Elymus junceus Fisch.)
Smooth bromegrass (Bromus inermis Leyss.)
Alfalfa (Medicago sativa L.)
Sudangrass (Sorghum bicolor (L.) Moench.)

pasture number and size for each rep and period. Cattle in pasture Systems 1 and 2 were placed in pastures with crested wheatgrass in Period 1. In Period 2, the cattle were moved onto either native or native-interseeded range and the cattle stayed in these pastures through Period 3. In Period 4, the cattle were moved to new ungrazed pastures that were either native or native-interseeded range. Therefore, each cow-calf unit grazed on three separate pastures during the five periods.

In Systems 3 and 4 the cattle started out on Russian wildrye in Period 1, were moved to either native or native-interseeded pasture for Periods 2 and 3 and were moved back to the initial Russian wildrye pastures in Periods 4 and 5.

In Systems 5 and 6, the cattle were placed in pastures with a crested wheatgrass-alfalfa mixture in Period 1. In Period 2, they were moved to pastures with a bromegrass-alfalfa mixture. In Peirods 3, 4 and 5, the cattle were placed in either native or native-interseeded pastures, and they remained in the same pasture for all three periods.

All of the tame pastures in the first four systems received a top-dressing of nitrogen (applied in the form of ammonium nitrate) at the rate of 37 kg per hectare per year.

The species composition of the native and tame pastures was not determined, but it would be expected to be similar to the composition found by Fransen (7) at the same location.

Statistical Design and Data Collection:

Six cow-calf units as tester animals were assigned to each of 3

replications per pasture system in 1980 to 1982. The tester units were randomly assigned using calf sex and weights as restrictions in the randomization. Each pasture had an equal number of cow and bull calves. Calves were also divided up into three weight classes so that each pasture randomly received units from each weight class within each sex group. In 1983 five tester animals were used and the above randomization was followed where permitted. Put-and-take animals were utilized to adjust the grazing pressure on each pasture. These put-and-take animal units (cow and calf) were assumed to gain at the same rate as the tester animals. In 1983, sufficient cow-calf units were not available for put and take animals so steers and bulls were used on the assumption that they gained at the same rate as the tester. Pastures were selected to be as uniform as possible. Animal shrunk weights were taken at the beginning and end of the grazing season. Animals were also weighed without shrinking at the beginning and end of each period (approximately 30-35 day intervals). The following calculations were made on the cattle data

1. Calendar days = Last day on pasture - First day on pasture.
2. Grazing days = Calendar days x Number of grazing animals.
3. Average daily gain (ADG) = (Final weight - Initial weight)/ calendar days.
4. Total gain = Average daily gain x Grazing days.
5. Gain per hectare = Total gain/no. of hectares.

PROC ANOVA within SAS, Statistical Analysis System (21), was used to analyze balanced data. Proc GLM was used to analyze unbalanced data.

Forage Sampling:

Samples used to estimate available forage, were collected at the completion of each grazing period by clipping plant material within a quadrant 30.5 x 122 cm. Four samples were taken randomly in each pasture and placed in paper bags for drying. However, the samples for periods 4 and 5 in 1980 were lost.

The samples were dried at 56° C in forced air ovens and dry weights were taken. Samples were ground, to pass through a 40 mesh Wiley mill screen, and used for protein analysis.

Protein Analysis:

The four samples from each pasture were composited and used for protein determinations using the standard Kjeldahl method which is as follows:

I. Digestion Procedure:

a. Weighed 1.00 g dried-ground sample into 800 ml. Kjeldahl flask.

b. Added 10.0 g K_2SO_4 and 0.3 g Cu SO_4 and two glass boiling beads.

c. Added 25 ml. concentrated H_2SO_4 from the dispensing buret.

d. Digested for 30 min.

II. Distillation:

a. Added 50 ml of boric acid to Erlenmeyer flasks and inserted the condenser tube into the flask.

b. Added 400 ml. of water first, then 100 ml. of NaOH to the Kjeldahl digest flasks.

c. Allowed the flask to distill until about 250 ml. of distillate had been collected in the Erlenmeyer.

III. Titration:

a. Added 5 drops of Methylene blue (indicator).

b. Titrated to a natural gray end point.

IV. Calculation:

% Protein = ml. acid titrated x acid normality x 1.4 x 6.25.

Climatic Data:

The climatic data for 1980-1983 are recorded in Appendix 1, 2, 3 and 4 respectively. The maximum, minimum, and monthly average temperature with total precipitation and departure from normal are from the standard U.S. Weather Bureau Station at Faulkton, South Dakota.

RESULTS AND DISCUSSION

I. Crude Protein Percent:

The chemical composition of forage is an indicator of the nutritive value of the forage which is related to requirements for good health, growth and productiveness of animals. The chemical composition depends on several factors such as type of plant, (whether grass, legume, or a mixture of both) and the plant environment during growth. The protein requirement of an animal is essentially the sum of the requirements for individual amino acids. This requirement is generally estimated by measuring crude protein in forages. In general, diet requirements of a 100-400 pound calf for percent crude protein is 11 to 14 percent and for a lactating cow is 12 to 18 percent.

The analyses of variance for percent crude protein for each year are in Appendix 5. System, period, and system-by-period interaction had a highly significant effects on percent crude protein. Replication and replication interactions with system and period had no significant effect.

The crude protein percentage for the six pasture systems during the years of study are presented in Tables 2, 3, 4 and 5. Systems that included interseeding with alfalfa produced forage with approximately one percent more protein than the native systems. Alfalfa is high in protein in relation to animal requirements. System 6 produced significantly higher protein than the other systems with 12.40, 10.60, 10.70 and 10.35 percent crude protein for 1980, 1981, 1982 and 1983, respectively.

Table 2. Percent Crude Protein of Six Pasture Systems, 1980.

Pasture System	Time Period: April 24-May 30	May 31-June 30	July 1-Aug 4	Mean
1	Crested	Native		10.70d
	15.20	8.90	8.00	
2	Crested	Interseeded		11.90b
	16.20	10.00	9.50	
3	Russian Wildrye	Native		10.50d
	15.60	8.40	7.60	
4	Russian Wildrye	Interseeded		11.70c
	15.40	10.20	9.50	
5	Crested-Alfalfa	Brome-Alfalfa	Native	11.60c
	17.00	10.10	7.80	
6	Crested-Alfalfa	Brome-Alfalfa	Interseeded	12.40a
	17.50	10.40	9.20	
Mean	16.10a	9.70b	8.60c	

Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 3. Percent Crude Protein of Six Pasture Systems, 1981.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native				
	15.50	8.50	7.30	6.80	6.50	8.90f
2	Crested	Interseeded				
	15.10	10.10	9.20	8.30	7.30	10.00b
3	Russian Wildrye	Native		RWR*	Sudan	
	15.10	8.40	7.80	7.40	6.90	9.10e
4	Russian Wildrye	Interseeded		RWR*	Sudan	
	14.90	10.20	8.90	7.50	7.20	9.70d
5	Crested-Alfalfa	Br. Alf.**	Native Ranges			
	17.60	10.30	7.70	7.20	6.60	9.90c
6	Crested-Alfalfa	Br. Alf.**	Interseeded Ranges			
	17.80	10.20	9.10	8.20	7.50	10.60a
Mean	16.00a	9.60b	8.30c	7.60d	7.00e	

* Russian Wildrye
** Brome-Alfalfa
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 4. Percent Crude Protein of Six Pasture Systems, 1982.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native Ranges				
	16.20	8.90	7.60	7.30	6.70	9.30d
2	Crested	Interseeded Ranges				
	15.70	10.30	9.60	8.40	7.60	10.30b
3	Russian Wildrye	Native		RWR*		
	15.30	8.80	7.90	7.60	7.40	8.40d
4	Russian Wildrye	Interseeded		RWR*		
	15.40	11.10	9.50	8.40	7.60	10.40b
5	Crested-Alfalfa	Brome-alf.**	Native Ranges			
	17.70	10.50	7.80	7.30	6.60	9.90c
6	Crested-Alfalfa	Brome-alf.**	Interseeded Ranges			
	17.80	10.40	9.30	8.40	7.50	10.70a
Mean	16.40a	10.00b	8.60c	7.90d	7.20e	

* Russian wild rye
** Brome-alfalfa
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 5. Percent Crude Protein of Six Pasture Systems, 1983.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native Ranges				
	15.30	8.40	7.30	6.50	6.30	8.76e
2	Crested	Interseeded Ranges				
	15.10	10.20	9.20	8.30	7.40	10.04b
3	Russian Wildrye	Native		RWR*		
	15.50	8.30	7.40	6.90	6.40	8.90d
4	Russian Wildrye	Interseeded		RWR*		
	14.70	10.10	8.50	8.30	7.60	9.84c
5	Crested-Alfalfa	Brom.-Alf.**	Native Ranges			
	17.10	10.30	7.80	7.30	6.40	9.78c
6	Crested-Alfalfa	Brom.-Alf.**	Interseeded Ranges			
	17.10	10.10	9.10	8.20	7.40	10.38a
Mean	15.80a	9.57b	8.22c	7.58d	6.92e	

* Russian wild rye

** Brome-alfalfa

Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

The effect of periods on crude protein is presented in Tables 2, 3, 4 and 5. Protein decreased from the first period to the last in all years with percent crude protein during the first period being considerably greater than all other periods. This decrease may be attributed to the following:

1) As the plant matures, the size of new cells declines, and the ratio of cell surface area to cell volume increases. Since the cell walls correspond to surface area and contain protein and other compounds that are primarily non-digestible, the crude protein which is primarily found in the cell volume decreases.
2) Environmental conditions also create differences in protein percent.

Crude protein for the dry season of 1980 is in Table 2. There was not a great deal of variation among the pasture systems in Period 1 except that the crested-alfalfa was greater in percent crude protein than the other two tame pastures. In the other periods where native and interseeded-native pastures were utilized, the interseeded ranges produced more percent crude protein than the non-interseeded ranges. Also, in Period 2, tame pastures that were seeded with alfalfa produced as much or more forage as native pastures interseeded with alfalfa. The highest crude protein produced from the interseeded native range was 10.20 percent in Period 2 of pasture System 4, whereas native range produced only 8.90 percent in Period 2 of pasture System 1. Overall, interseeded ranges exceed non-interseeded ranges by about 1.3 percent crude protein. Similar trends were observed in the other three years of the study (Tables 3, 4 and 5). The tame pastures in Period 1

produced enough crude protein to meet the cow-calf requirements. After the first period interseeded and non-interseeded ranges and tame pastures fell below the requirement; therefore, animals would have had to eat more low quality forage in order to gain sufficient protein.

II. Available Forage, Dry Matter Yield:

The analyses of variance of forage availability for the different years of the study are presented in Appendix 6. Highly significant differences existed for period, system and period-by-system interaction in the four years of the study. However, replications and its interactions had no significant effect on forage dry matter.

The availability of forage dry matter, in kg/ha, for the six pasture systems in the years of the study are presented in Tables 6, 7, 8 and 9. System 6 was significantly higher in forage availability than the other systems and had 2,125, 2,072, 2,174 and 1,992 kg/ha of remaining forage for 1980, 1981, 1982 and 1983, respectively. The systems with interseeded ranges generally yielded as much or more available forage than systems with native ranges.

Forage availability was highest during the second period which differed significantly from the other periods. The higher yield of the second period was attributed to the presence of alfalfa-brome grass in Systems 5 and 6. Brome being a cool season grass and alfalfa, a cool season legume, started their growth earlier in the year and therefore had a longer period of growth before the beginning of Period 2 than the warm season grasses in native and interseeded ranges. The rather low values for available forage during Period 1 can be attributed to

Table 6. Available forage kg/ha, of post-grazing samples, 1980.

Pasture System	Time Period: April 24-May 30	May 31-June 30	July 1-Aug 4	Mean
1	Crested	Native		
	739.00	1515.00	828.00	1025.00c
2	Crested	Interseeded		
	1105.00	1792.00	1426.00	1141.00dc
3	Russian Wildrye	Native		
	1403.00	1769.00	1334.00	1505.00bc
4	Russian Wildrye	Interseeded		
	1149.00	2068.00	1799.00	1672.00bc
5	Crested-Alfalfa	Brome-Alfalfa	Native	
	1956.00	3218.00	1134.00	2103.00a
6	Crested-Alfalfa	Brome-Alfalfa	Interseeded	
	1485.00	3150.00	1739.00	2125.00a
Mean	1306.00b	2252.00a	1378.00b	

Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 7. Available forage, kg/ha, of post-grazing samples, 1981.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native				
	821.00	1388.00	963.00	724.00	545.00	888.00e
2	Crested	Interseeded				
	313.00	2045.00	1605.00	1187.00	948.00	820.00cd
3	Russian Wildrye	Native		RWR*	Sudan	
	1560.00	1403.00	1202.00	955.00	574.00	1139.00d
4	Russian Wildrye	Interseeded		RWR*	Sudan	
	1045.00	2045.00	1620.00	1164.00	948.00	1194.00bc
5	Crested-Alfalfa	Brom.-Alf.**	Native Ranges			
	1717.00	3024.00	985.00	754.00	522.00	1400.00b
6	Crested-Alfalfa	Brom.-Alf.**	Interseeded Ranges			
	3210.00	3397.00	1605.00	1172.00	978.00	2072.00a
Mean	1444.00b	2217.00a	1330.00b	993.00e	594.00d	

* Russian wild rye
** Brome-alfalfa
Marginal means followed by the same letter or letters in common do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 8. Available forage, kg/ha, of post-grazing samples, 1982.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native				
	1545.00	1605.00	1187.00	978.00	761.00	1215.57d
2	Crested	Interseeded				
	1665.00	2322.00	1859.00	1366.00	1157.00	1674.00c
3	Russian Wildrye	Native		RWR*		
	2650.00	1627.00	1172.00	2023.00	1508.00	1796.00b
4	Russian Wildrye	Interseeded		RWR*		
	2658.00	3188.00	1821.00	2210.00	1261.00	2228.00a
5	Crested-Alfalfa	Br.-Alf.**	Native Ranges			
	1836.00	4390.00	1157.00	963.00	769.00	1823.00b
6	Crested-Alfalfa	Br.-Alf.**	Interseeded Ranges			
	2478.00	4084.00	1806.00	1373.00	1127.00	2174.00a
Mean	2139.00b	2869.00a	1500.00c	1485.00c	1697.00d	

* Russian wild rye
** Brome-alfalfa
Marginal means followed by the same letter or letters in common do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 9. Available forage, kg/ha, of post-grazing samples, 1983.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native				
	2673.00	2195.00	948.00	709.00	686.00	1442.00d
2	Crested	Interseeded				
	2546.00	2688.00	1605.00	1187.00	1120.00	1829.00a
3	Russian Wildrye	Native		RWR*		
	1553.00	1769.00	1179.00	1500.00	948.00	1390.00d
4	Russian Wildrye	Interseeded		RWR*		
	1209.00	2889.00	1612.00	1164.00	1134.00	1602.00ab
5	Crested alfalfa	Br.-alf.**	Native			
	1956.00	3091.00	970.00	754.00	739.00	1502.00cd
6	Crested alfalfa	Br.-alf.**	Interseeded			
	3038.00	2986.00	1627.00	1179.00	1127.00	1992.00a
Mean	2162.00b	2603.00a	1324.00c	1082.00d	959.00d	

* Russian wildrye
** Brome-alfalfa
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

the fact that the cattle were allowed to graze these pastures before considerable growth could accumulate. The available forage generally decreased after the second period. This decrease paralleled the decrease in precipitation during these periods.

The system-by-period interaction was highly significant. The crested-alfalfa pastures in Period 1 generally produced as much or more available forage than the other tame pastures (Tables 6 and 8) for 1980 and 1982, respectively. In 1981 and 1983 (Tables 7 and 9), considerable variation existed in available forage produced in pastures with the same vegetation in the same period. This variation could have been due to a number of factors. Russian wildrye produced more available forage than crested wheatgrass in every year except 1983. In the second period, the brome-alfalfa mixture (period two) produced more available forage than all other pastures throughout the four years of study. The interseeded pastures produced more available forage than the native ranges in all periods. During the second period, the interseeded native pastures produced 276 kg/ha more forage than the non-interseeded pastures, whereas for Period 3 an increase of 597 kg/ha was recorded for interseeded over non-interseeded pastures. In Periods 4 and 5, the Russian wildrye had as much or more available forage as the native-interseeded pastures. In general, the increase in forage from interseeded native pastures over non-interseeded native pastures during each period was due to alfalfa.

III. Total Protein Per Hectare:

Total protein is a measure of percent crude protein x forage

availability. Analyses of variance for total protein per hectare for each year are presented in Appendix 7. System, period and system by period interaction had highly significant effects on total protein per hectare. Replication and replication interactions with system and period had no significant effect on total protein per hectare.

The total protein per hectare was generally highest in System 6 and lowest in System 1 (Tables 10, 11, 12 and 13). Also systems that were interseeded with alfalfa had more total protein per hectare than the native systems.

Total protein per hectare was significantly different for periods in each year. Total protein per hectare decreased from the first to the fifth period in all years except 1980, with the total protein of the first period being considerably greater than all other periods in 1981 to 1983. This is attributed to the general decline in rainfall towards the end of the season and the fact that high air temperatures in July and August contribute to high evapotranspiration during these months (Appendices 1, 2, 3 and 4). Both factors combine to lower yields.

In the period x system interaction, the crested-alfalfa was usually found to be equal to or greater in total protein than the other two tame pastures in Period 1. In the other periods, where interseeded and non-interseeded pastures were utilized, interseeded ranges yielded about 60 kg more total protein per hectare than the non-interseeded ranges. The brome-alfalfa produced at least 10 kg/ha more total protein per hectare than the other pastures in Period 2 (except in 1983)

Table 10. Total protein, kg/ha, of six pasture systems, 1980.

Pasture System	Time Period: April 24-May 30	May 31-June 30	July 1-Aug 4	Mean
1	Crested	Native		
	112	134	66	104d
2	Crested	Interseeded		
	179	179	121	159c
3	Russian Wildrye	Native		
	218	142	102	156c
4	Russian Wildrye	Interseeded		
	176	210	170	185b
5	Crested-Alfalfa	Brome-Alfalfa	Native	
	332	334	88	251a
6	Crested-Alfalfa	Brome-Alfalfa	Interseeded	
	259	318	159	245a
Mean	212a	220a	117b	

Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 11. Total protein, kg/ha, for the six pasture systems, 1981.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native				
	128	117	70	49	35	79e
2	Crested	Interseeded				
	147	206	147	98	69	113d
3	Russian Wildrye	Native		RWR*	Sudan	
	235	117	93	70	39	110d
4	Russian Wildrye	Interseeded		RWR*	Sudan	
	155	208	144	85	68	132c
5	Crested-Alfalfa	Br. Alf.**	Native Ranges			
	302	311	75	54	34	155b
6	Crested-Alfalfa	Br. Alf.**	Interseeded Ranges			
	571	346	146	96	73	246a
Mean	239a	217a	112b	75c	53d	

* Russian Wildrye
** Brome-Alfalfa
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 12. Total protein, kg/ha, for the six pasture systems, 1982.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native				
	250	142	90	71	50	120d
2	Crested	Interseeded				
	251	239	177	114	87	175c
3	Russian Wildrye	Native		RWR*		
	405	143	92	153	111	180c
4	Russian Wildrye	Interseeded		RWR*		
	409	353	172	185	95	242a
5	Crested-Alfalfa	Br. Alf.**		Native Ranges		
	324	460	90	70	50	198b
6	Crested-Alfalfa	Br. Alf.**		Interseeded Ranges		
	441	424	175	115	84	248a
Mean	348a	293b	132c	118d	79e	

* Russian Wildrye
** Brome-Alfalfa
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 13. Total protein, kg/ha, for the six pasture systems, 1983.

Pasture System	May 9-June 2	Time Period: June 3-July 8	July 9-Aug 11	Aug 12-Aug 25	Aug 26-Sep 16	Mean
1	Crested	Native				
	408	184	71	46	43	150ed
2	Crested	Interseeded				
	384	274	157	98	82	199b
3	Russian Wildrye	Native		RWR*		
	240	146	87	96	60	125e
4	Russian Wildrye	Interseeded		RWR*		
	177	291	137	100	82	157c
5	Crested-Alfalfa	Br. Alf.**		Native Ranges		
	334	318	75	55	47	165c
6	Crested-Alfalfa	Br. Alf.**		Interseeded Ranges		
	519	301	148	103	83	230a
Mean	343a	252b	112c	83c	66d	

* Russian Wildrye
** Brome-Alfalfa
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

and all subsequent periods. Brome-alfalfa mixtures contributed more forage and had as high or higher percent crude protein than the other pastures during these periods.

IV. Animal Production on Pasture:

A. Average daily gain (ADG), kg:

1. Calf:

The analysis of variance of ADG's using shrunk weights is presented in Appendix 8. Highly significant differences existed for years. However, systems, replications and their interactions with year had no significant effect on ADG's.

Animal production for the six grazing management systems by year is presented in Table 14. These gains were calculated using shrunk weights of the animals taken at the beginning and end of the grazing season. However, comparisons between years was difficult since calf weights and age were not the same each year (Appendix 16). The lowest ADG's occurred in 1980, which were significantly lower than the average of the ADG's for the other years using orthogonal contrasts (Appendix 9 and Table 14). These low values in 1980 were attributed to the severe drought which retarded forage production and low initial calf weights. Average daily gains in 1983 were the highest and differed significantly from the average gains in 1981 and 1982. Initial calf weights in 1983 were intermediate between 1981 and 1982. Average daily gains in 1981 and 1982 were not significantly different from each other even though initial calf weights were higher in 1982.

The analyses of variance by year for ADG's using unshrunk

Table 14. Calf Production in ADG* and G/ha* During 1980-1983 Grazing Season

Pasture System	1980		1981		1982		1983		Mean	
	ADG*	G/ha+	ADG*	G/ha+	ADG*	G/ha+	ADG*	G/ha+	ADG*	G/ha+
1	0.69	29.00	0.81	34.00	0.80	46.00	0.85	38.00	0.79	36.00
2	0.65	39.00	0.89	49.00	0.80	53.00	0.84	50.00	0.79	47.00
3	0.77	29.00	0.77	31.00	0.86	37.00	0.85	40.00	0.81	34.00
4	0.69	32.00	0.78	40.00	0.85	45.00	0.90	50.00	0.81	42.00
5	0.64	18.00	0.73	24.00	0.80	32.00	0.82	28.00	0.75	25.00
6	0.67	22.00	0.83	30.00	0.76	35.00	0.88	34.00	0.79	30.00
Mean	0.68	28.67	0.80	35.00	0.81	41.00	0.86	40.5		

* ADG = Calf Average Daily Gain, kg.
+ G/ha = Gain Per Hectare, kg/ha.

weights are presented in Appendix 10. System was the only factor that produced a significant effect on ADG in 1980. Period had a significant effect on ADG in the other years of the study. However, in 1981, the period by system interaction was also significant.

Animal production for each period within each year for the six pasture systems is presented in Tables 15, 16, 17 and 18. Means in these tables were determined on the unshrunk weights. In 1980 (Table 15), ADG's for pasture Systems 4 and 6 were significantly higher than the other systems. The systems with interseeded ranges generally produced higher ADG's than systems with non-interseeded ranges.

Average daily gains (Tables 16, 17 and 18) were significantly different for periods in 1981, 1982 and 1983. Average daily gains in the first period and the fourth period were considerably higher than in all other periods in 1981 and 1982 (Tables 16 and 17). In the first period, the increase in ADG's probably was due to the higher crude protein percent of the forage. The increase in the fourth period was due to the fact that the cattle were placed in pastures that either had not been grazed yet (Systems 1 and 2) or had been allowed to regrow following grazing during Period 1 (Systems 3 and 4). The fifth period had the lowest ADG's, this due to the fact that the crude protein content had decreased, an indication of lower quality forage as the season progressed and there was less forage during this period.

The system by period interaction was highly significant during the year of 1981. The crested-alfalfa pastures in Period 1 (Table 16) produced as much or more ADG's than the other tame pastures during this

Table 15. Animal Production in ADG* and G/ha+ of Calves for the Different Time Periods of Six Pasture Management Systems During 1980.

Pasture System		Time Period				
	Apr 24-May 30	May 31-June 30	July 1-Aug 4	Aug 5-Aug 12	Aug 13-Aug 25	Mean
1	Crested	Native Ranges				
ADG*	0.64	0.87	0.75	0.53	0.82	0.72 cb
G/ha+	62.90	20.27	10.03	7.90	5.60	21.34
2	Crested	Interseeded Ranges				
ADG*	0.61	0.94	0.76	0.78	0.77	0.77 b
G/ha+	51.90	23.35	19.15	10.43	7.17	22.38
3	Russian Wildrye	Native		Sudan	RWR	
ADG*	0.72	0.79	0.88	0.02	1.32	0.75 b
G/ha+	59.60	12.33	20.67	0.60	29.30	24.50
4	Russian Wildrye	Interseeded		Sudan	RWR	
ADG*	0.68	0.91	0.89	1.15	0.54	0.71 cb
G/ha+	55.50	33.40	11.41	8.40	6.39	23.91
5	Crested-Alfalfa	Brom.-Alf.	Native Ranges			
ADG*	0.93	0.76	0.78	1.15	0.54	0.71 cb
G/ha+	60.00	33.40	11.41	8.40	6.39	23.91
6	Crested-Alfalfa		Interseeded Ranges			
ADG*	1.02	0.65	0.78	0.87	0.77	0.82 a
G/ha+	65.80	28.80	17.20	12.77	5.60	26.48
Mean ADG	0.77	0.82	0.81	0.62	0.90	
G/ha	59.28 a	53.67 a	16.91 b	8.53 d	13.24 c	

* ADG = Calf Average Daily Gain kg.
+ G/ha = Gain, kg/hectare.
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 16. Animal Production in ADG* and G/ha+ of Calves for the Different Time Periods of Six Pasture Management Systems During 1981.

Pasture System		Time Period				
	Apr 24-May 30	May 31-June 30	July 1-Aug 4	Aug 5-Aug 12	Aug 13-Aug 25	Mean
1	Crested	Native Ranges				
ADG*	0.95	0.75	0.96	1.52	0.74	0.98
G/ha+	49.58	11.66	17.28	21.23	13.32	22.61
2	Crested	Interseeded Ranges				
ADG*	1.05	0.96	1.02	1.38	1.13	1.11
G/ha+	53.29	19.32	22.41	23.91	17.18	27.22
3	Russian Wildrye	Native		RWR	Sudan	
ADG*	1.01	0.73	1.03	1.32	0.03	0.83
G/ha+	39.04	11.70	17.24	32.00	0.65	20.26
4	Russian Wildrye	Interseeded		RWR**	Sudan	
ADG*	1.05	0.78	1.04	1.36	0.36	0.92
G/ha+	39.94	16.07	23.87	31.30	9.45	24.13
5	Crested-Alfalfa	Brom.-Alf.	Native Ranges			
ADG*	1.29	0.66	0.95	0.53	0.96	0.88
G/ha+	90.28	28.72	12.72	37.35	14.85	30.78
6	Crested-Alfalfa	Brom.-Alf.	Interseeded Ranges			
ADG*	1.28	0.59	0.94	0.75	1.13	0.94
G/ha+	89.18	25.35	18.90	47.11	17.18	31.58
Mean ADG	1.11 a	0.75 c	0.99 b	1.14 a	0.73 c	
G/ha	60.22 a	18.80 b	18.79 b	20.59 b	14.31 c	

* ADG = Calf Average Daily Gain kg.
\+ G/ha = Gain, kg/hectare.
** RAW = Russian Wildrye
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 17. Animal Production in ADG* and G/ha+ of Calves for the Different Time Periods of Six Pasture Management Systems During 1982.

Pasture System		Time Period				
	Apr 24-May 30	May 31-June 30	July 1-Aug 4	Aug 5-Aug 12	Aug 13-Aug 25	Mean
1	Crested	Native Ranges				
ADG*	1.04	0.72	0.82	0.88	0.23	0.74
G/ha+	79.42	11.01	14.46	18.55	4.42	25.57
2	Crested	Interseeded Ranges				
ADG*	0.99	0.79	0.84	1.38	1.08	1.02
G/ha+	73.03	18.74	21.74	23.91	20.15	31.51
3	Russian Wildrye	Native		RWR**		
ADG*	0.94	0.84	0.63	1.74	0.53	0.93
G/ha+	30.85	12.87	16.62	33.24	15.95	29.91
4	Russian Wildrye	Interseeded		RWR**		
ADG*	0.92	0.79	1.33	0.85	0.63	0.83
G/ha+	50.00	16.75	19.79	16.83	8.56	26.36
5	Crested-Alfalfa	Brom.-Alf.	Native Ranges			
ADG*	1.03	1.00	0.94	0.53	0.96	0.89
G/ha+	90.88	39.44	12.69	7.35	14.55	30.98
6	Crested-Alfalfa	Brom.-Alf.	Interseeded Ranges			
ADG*	1.10	0.88	0.75	0.75	1.13	0.90
G/ha+	95.69	29.98	18.90	7.11	17.18	30.97
Mean ADG	1.00 a	0.83 b	0.83 b	1.02 a	0.76 c	
G/ha	75.95 a	21.47 b	17.37 c	17.27 c	14.04 d	

* ADG = Calf Average Daily Gain kg.
\+ G/ha = Gain, kg/hectare.
** RAW = Russian Wildrye
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

Table 18. Animal Production in ADG* and G/ha+ of Calves for the Different Time Periods of Six Pasture Management Systems During 1983.

Pasture System		Time Period				
	Apr 24-May 30	May 31-June 30	July 1-Aug 4	Aug 5-Aug 12	Aug 13-Aug 25	Mean
1	Crested	Native Ranges				
ADG*	0.95	1.08	0.73	0.79	0.55	0.82
G/ha+	47.62	15.82	15.87	18.40	17.25	27.59
2	Crested	Interseeded Ranges				
ADG*	1.03	0.88	0.85	0.53	0.75	0.81
G/ha+	49.64	19.20	16.36	20.91	38.42	28.91
3	Russian Wildrye	Native		RWR**		
ADG*	0.98	0.95	0.84	0.77	0.52	0.81
G/ha+	61.44	12.43	12.87	29.39	12.74	25.78
4	Russian Wildrye	Interseeded		RWR**		
ADG*	1.03	1.14	0.78	0.77	0.55	0.85
G/ha+	67.93	28.58	21.45	29.39	17.87	33.44
5	Crested-Alfalfa	Brom.-Alf.	Native Ranges			
ADG*	1.13	0.96	0.64	0.84	0.44	0.80
G/ha+	76.55	30.03	27.79	14.32	7.42	31.22
6	Crested-Alfalfa	Brom.-Alf.	Interseeded Ranges			
ADG*	1.13	0.94	0.74	0.90	0.51	0.85
G/ha+	76.99	28.61	27.85	5.29	8.90	29.53
Mean ADG	1.04aa	0.99 b	0.76 c	0.77 c	0.55 d	
G/ha	63.70 a	22.45 c	20.37 c	49.62 b	17.10 d	

* ADG = Calf Average Daily Gain kg.
\+ G/ha = Gain, kg/hectare.
** RAW = Russian Wildrye
Marginal means followed by the same letter do not differ significantly from each other using the Duncan-Waller test at K-Ratio = 100.

period. Russian wildrye had about the same ADG as crested wheatgrass. In the second period the brome-alfalfa mixtures provided less ADG than native or interseeded pastures. The interseeded pastures in most cases produced more ADG's than non-interseeded pastures in every period that these pastures were used. The lowest ADG was obtained in sudangrass (Systems 3 and 4 in Period 5).

2. Cow:

The analysis of variance of ADG's using shrunk weights for the cow data is presented in Appendix 11. Highly significant differences were produced over years. However, systems, replications and their interactions with year had no significant effect on ADG's.

Cow production for the six grazing management systems by year is presented in Table 19. These gains were calculated using shrunk weights of the animals taken at the beginning and end of the grazing season. The lowest ADG's occurred in 1980, and were significantly lower than the average of the ADG's for the other years. Negative ADG's were obtained in 1980. These negative values were evident in Systems 1, 3, 4 and 5; therefore these systems did not provide adequate forage for grazing in 1980 due to lower than average precipitation. Average daily gains in 1983 were significantly greater than in 1981 and 1982. Pasture System 2 produced the highest ADG and Systems 3 and 4 tended to be higher in ADG's across years of the study than the other remaining systems, but these differences were not significant at P = 0.05.

Table 19. Cow production in ADG* and G/ha+ during 1980 to 1983 grazing season.

	1980		1981		1982		1983		Mean	
Pasture System	ADG*	G/ha+	ADG*	G/ha+	ADG*	G/ha+	ADG*	G/ha+	ADG*	G/ha+
1	-0.10	-4.00	0.28	10.00	0.28	16.00	0.43	17.00	0.22	10.00
2	0.16	6.00	0.49	21.00	0.34	23.00	0.45	23.00	0.36	18.00
3	-0.05	-1.00	0.49	15.00	0.41	16.00	0.44	17.00	0.33	11.00
4	-0.13	0.60	0.39	16.00	0.51	23.00	0.48	21.00	0.31	15.00
5	-0.05	-1.00	0.29	7.00	0.32	13.00	0.39	12.00	0.24	8.00
6	0.02	2.00	0.12	4.00	0.25	14.00	0.43	12.00	0.21	9.00
Mean	0.008	0.28	0.34	12.00	0.35	18.00	0.43	17.00		

* ADG = Cow average daily gain, kg.
+ G/ha = Cow gain per hectare, kg/ha.

B. Gain per hectare, kg/ha:

1. Calf:

The analysis of variance for gain per calf using shrunk weights is presented in Appendix 12. There were highly significant differences for systems and years.

Gains per hectare from cattle shrunk weights for the six grazing management systems by year are presented in Table 14 and orthogonal contrasts are in Appendix 19. System 2 had the highest gain per hectare across years of the study. The lowest gain was obtained from pasture System 5. The average G/ha of System 5 and 6 was significantly lower than the average of System 1, 2, 3 and 4. Average gains of System 1 and 2 were significantly higher than the average of System 3 and 4. Interseeded pasture systems produced significantly more G/ha than non-interseeded pasture systems.

The lowest gain per hectare was obtained in 1980. This was significantly lower than the average of the G/ha for the other years (orthogonal contrasts Appendix 13 and Table 14). These low gains in 1980 were due to the severe drought. Gains per hectare in 1982 were the highest, which differed significantly from the average of 1981. These higher gains in 1982 were likely due to above normal precipitation during the first half of the grazing period.

The analyses of variance for gains per hectare calculated on unshrunk weights are presented in Appendix 14. Period had a significant effect on G/ha in the four years of the study. In 1980 and 1981 the period-by-system interaction was also significant.

Gains per hectare based on unshrunk weights for the different pasture components of six pasture systems, during 1980 is presented in Table 15. Period 1 and 2 produced the highest G/ha, which differed significantly from other periods. This could be attributed to high crude protein content of the forage as well as the amount of forage available during these periods. The lowest G/ha was obtained in Period 5; therefore, the lower the quality and quantity of forage, the lower animal gains per hectare. The lowest G/ha occurred in the fifth period in every year but 1983 (Tables 16, 17, 18 and 19), whereas Period 1 had the highest G/ha throughout the years of study.

The period x system interaction was significant only in the years of 1980 and 1981. In Period 1 of both years, the crested-alfalfa pastures produced as much or more G/ha than the other tame pastures (Table 15 and 16). This was most likely due to the high crude protein of the forage. In the second period of these years, the brome-alfalfa mixture produced more gain per hectare than all other pastures. This pasture mixture produced high amounts of total protein per hectare. Russian wildrye in Period 4 (Table 16) produced as much or more G/ha than interseeded and non-interseeded pastures. In Period 5 (Table 15) Russian wildrye more had G/ha than interseeded and non-interseeded pastures. Comparatively, interseeded pastures had higher G/ha than non-interseeded pastures in almost every period where both were used. The presence of alfalfa in interseeded native pastures increased the amount of available forage and the crude protein content of that forage.

2. Cow:

The analysis of variance for gain per hectare using shrunk weights is presented in Appendix 15. Highly significant differences were found for systems, years, and system x year interaction.

Gains per hectare from cattle shrunk weights for the six grazing management systems by year are presented in Table 19 and orthogonal contrasts are in Appendix 21. The highest gain was observed in pasture System 2 (crested wheat grass -- interseeded). The average gains in System 5 and 6 were significantly lower than the average gains in System 1, 2, 3 and 4. Average gains of System 1 and 2 was higher than the average of System 3 but the difference was not significant. In general, systems that were interseeded with alfalfa significantly higher gains than the corresponding non-interseeded pasture systems. The lowest G/ha was observed in 1980, which was significantly lower than the average of the gains for the other years (Appendix 20). These low values in 1980 were due to the severe drought. These negative values were evident in Systems 1, 3, and 5; therefore, these systems did not provide adequate forage for grazing in 1980. The difference in gains of 1982 and 1983 was not significant but the average of the two were significantly higher than gains of 1981.

The data for the system-by-year interaction are in the body of Table 19. There was not much difference in G/ha between the tame pasture systems of crested, Russian wildrye and crested-alfalfa in 1980. However, crested wheatgrass and Russian wildrye had higher G/ha than crested-alfalfa in the other years. In every case, G/ha in the

interseeded pasture systems was equal to or greater than the non-interseeded pasture systems except in 1981 G/ha in pasture Systems 5 and 6 where the reverse was true.

SUMMARY

Six pasture systems: (1) crested wheat grass - native; (2) crested wheatgrass - interseeded; (3) Russian wildrye - native; (4) Russian wildrye - interseeded; (5) crested-alfalfa - native and (6) crested-alfalfa - interseeded, were evaluated by grazing with cows and their calves. Three different parameters, namely, percent crude protein, as an estimation of forage quality, forage availabile after grazing and animal weights (ADG and G/ha) were used to measure pasture productivity.

Forage quality declined as the grazing season progressed. The quality of forage was lower in the native than in the interseeded pastures when sampled on the same dates. The difference in crude protein was due to the presence of alfalfa in interseeded pastures.

Forage growth in the Great Plains has been shown to be extremely dependent upon precipitation. Forage availability, estimated by post-grazing sampling, was highest in 1982 when above-normal rainfall was received. The severe drought condition of 1980 produced the lowest level of forage compared to the other years of this study.

The highest forage availability, across all years, was obtained in pasture System 6. Other interseeded pastures produced greater yields than non-interseeded pastures in every year of the study. Similar results were obtained for total crude protein.

There were no significant differences in cow or calf ADG's among the pasture systems. This lack of differences in ADG's between pasture systems may have been due to understocking of the pastures. However,

ADG's were maintained at .5 kg/ha or higher in the later stages of the grazing season in all systems except where sudan grass was used in Systems 3 and 4. Therefore, Systems 1, 2, 5 and 6 will maintain the ADG through the grazing season.

Gain per hectare per animal was highest for interseeded and lowest for the non-interseeded systems. This may be more a reflection of the pasture size since average daily gains were not significantly different. However, the interseeded pasture systems did produce the highest crude protein percentage, available forage per hectare and total crude protein per hectare; therefore, the interseeded pasture systems were probably better than the non-interseeded pasture systems. Pasture Systems 5 and 6 produced significantly lower gains than the average of the other two major systems (Systems 1 and 2 and Systems 3 and 4), but Systems 5 and 6 were higher in forage availability measured at the end of the grazing periods. Also, Systems 5 and 6 did not require the fertilizer input of the other systems. Therefore, no conclusion can be made as to which major pasture system was best but System 6 appears to have some advantages.

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Appendix 1
Precipitation and Temperature for 1980 at
Faulkton, South Dakota.

Month	Temperature (C) Average Maximum	Average Minimum	Monthly Average	Departure from Normal	Precipitation (cm)
January	- 3.2	-15.3	- 9.3	2.6	0.58
February	- 2.2	-14.2	- 8.2	- 0.6	1.00
March	4.6	- 8.3	- 1.8	0.1	0.98
April	19.5	1.5	10.5	5.4	3.20
May	25.5	7.4	16.5	5.1	1.88
June	28.3	13.8	21.06	4.0	6.33
July	33.0	15.2	24.1	3.1	7.23
August	30.9	14.4	22.7	1.4	6.13
September	26.5	8.8	17.7	3.3	1.43
October	16.6	1.5	9.05	- 1.2	4.28
November	10.0	- 3.0	3.5	5.9	0.25
December	0.2	-10.9	- 5.3	3.3	0.18

Appendix 2
Precipitation and Temperature for 1981 at
Faulkton, South Dakota.

Month	Temperature (C) Average Maximum	Average Minimum	Monthly Average	Departure from Normal	Precipitation (cm)
January	3.10	-12.6	- 4.8	10.8	Trace
February	4.30	- 9.9	2.8	9.1	0.08
March	12.7	- 5.6	3.6	9.8	8.63
April	20.4	2.9	11.7	7.5	0.25
May	21.6	5.60	13.6	- 0.1	3.03
June	26.9	11.2	19.1	0.4	5.45
July	31.6	15.8	23.6	2.4	8.08
August	29.9	15.20	22.6	1.3	8.58
September	27.5	8.40	17.9	3.8	1.10
October	15.9	3.30	9.6	- 0.2	6.43
November	9.8	- 2.8	3.5	5.9	3.05
December	- 3.6	-14.30	- 8.9	- 3.2	1.53

Appendix 3
Precipitation and Temperature for 1982 at
Faulkton, South Dakota.

Month	Temperature (C) Average Maximum	Average Minimum	Monthly Average	Departure from Normal	Precipitation (cm)
January	-11.0	-11.1	-17.7	-12.60	2.38
February	------	------	------	------	------
March	3.2	- 6.10	- 1.40	0.90	5.00
April	14.0	1.20	6.40	- 2.0	3.80
May	20.7	9.20	14.90	2.30	10.23
June	24.6	9.90	17.30	- 2.80	11.03
July	32.10	15.80	23.90	2.80	8.20
August	31.10	13.60	22.30	0.80	4.78
September	24.60	8.20	16.40	1.00	4.05
October	15.60	2.50	9.10	- 1.20	6.00
November	5.10	- 7.40	- 1.2	- 2.50	1.20
December	1.7	-12.1	- 4.2	- 2.2	0.85

Appendix 4
Precipitation and Temperature for 1983 at
Faulkton, South Dakota.

Month	Temperature (C) Average Maximum	Average Minimum	Monthly Average	Departure from Normal	Precipitation (cm)
January	2.44	-10.27	- 3.88	-10.00	0.20
February	5.55	- 7.6	- 1.00	-11.55	0.03
March	4.00	- 4.16	- 0.05	-16.22	5.28
April	11.77	- 1.27	5.27	-15.55	2.83
May	20.38	4.5	12.44	-19.38	6.25
June	25.83	11.88	18.88	-18.33	10.30
July	20.66	17.22	24.50	-16.05	10.78
August	30.60	14.40	15.40	8.27	7.25
September	26.20	8.46	12.63	7.40	2.20
October	16.03	2.43	5.98	7.40	7.23
November	4.27	- 3.5	0.39	----	2.35

Appendix 5.
Analyses of Variance of Crude Protein Percent for the Years 1980-1983.

Source of Variations	d.f.		Mean Squares			
	1980	1981-1983	1980	1981	1982	1983
Period	2	4	1204.6**	970.65**	969.63**	9269.54**
System	5	5	18.74**	18.38**	19.85**	56.38**
Period x System	10	20	5.73**	6.32**	6.25**	4.69**
Rep.	2	2	0.15	0.13	0.003	0.18
Period x Rep.	4	8	0.13	0.05	0.1	0.07
System x Rep.	10	10	0.08	0.08	0.22	0.09
Period x Syst. x Rep.	20	40	0.07	0.09	0.07	0.05
Error	86	150	0.09	0.08	0.09	0.08

** Significant at Probability = .01.

Appendix 6
Analyses of Variance of Forage Availability
for the Years 1980-1983.

Source of Variations	d.f.		Mean Squares			
	1980	1981-1983	1980	1981	1982	1983
Period	2	4	42,867.53**	48,376.57**	73,885.91**	79,227.80**
System	5	5	1,276.38**	16,959.66**	17,942.76**	71,140.11**
Period x System	10	20	4,768.49**	5,906.03**	10,095.07**	4,911.46**
Rep	2	2	753.94	368.39	167.15	225.62
Period x Rep	4	8	664.93	112.47	245.45	570.21
System x Rep.	10	10	795.37	357.29	259.18	670.82
Period x Syst. x Rep.	20	40	482.71	333.97	366.11	165.95
Error	97	150	289.89	74.16	246.10	497.18

** Significant at Prob. = .01.

Appendix 7
Analyses of Variance of Total Protein per Hectare
for the Years 1980-1983.

	d.f.		1980	1981	1982	1983
	1980	1981-1983	Mean Squares	Mean Squares	Mean Squares	Mean Squares
Period	2	4	0.048**	0.092**	0.152**	0.097**
System	5	5	0.022**	0.030**	0.028**	0.027**
Period x System	10	20	0.007**	0.0127**	0.0151**	0.0116**
Rep.	2	2	0.008	0.001	0.001	0.003
Period x Rep.	4	8	0.001	0.0002	0.0004	0.0005
System x Rep.	10	10	0.001	0.0004	0.0004	0.0006
Syst. x Per. x Rep.	20	40	0.001	0.0004	0.0005	0.0005
Error	86	150	0.007	0.033	0.085	0.063

** Significant at Probability = .01.

Appendix 8
Analysis of variance of ADG* of calves using shrunk weights for the six pasture systems for the years 1980 to 1983

Source	d.f.	Mean squares
Rep.	2	0.007
System (S)	5	1.333
Year (Y)	3	0.099**
Rep x System	10	0.004
Rep x Year	6	0.003
System x Year	15	0.005
Rep x System x Year	30	0.006
Error	343	0.025

** Significant at 0.01 probability level.
* ADG = Calf average daily gain, kg.

Appendix 9
Orthogonal contrasts among years for ADG* of calves using shrunk weights in the years 1980-1983.

	Years and means					
	1980	1981	1982	1983		
	0.68	0.80	0.81	0.86	MS	F
Contrast						
1	+3	-1	-1	-1	0.2774	92.46**
2		+1	+1	-2	0.0288	9.67**
3		+1	-1		0	0

* ADG = Calf average daily gain, kg.
** Significantly different at 0.01 probability level.

Appendix 10
Analyses of variance of the average daily gain of calves, 1980-1983.

	1980		1981		1982		1983	
	d.f.	Mean Squares	d.f.	Mean Squares	d.f.	Mean Squares	d.f.	Mean Squares
Period	4	0.037	4	4.415**	4	4.560**	4	4.830**
System	5	0.833*	5	0.339	5	0.440	5	0.211
Syst. x Period	20	1.21	20	0.785**	20	2.42	20	0.601
Rep.	2	0.473	2	0.583	2	0.150	2	0.153
Rep. x Period	8	0.461	8	0.555	8	0.580	8	0.280
Rep. x Syst.	10	0.210	10	0.235	10	0.480	10	0.320
Rep. x Syst. x Period	40	1.401	40	0.241	40	1.32	40	0.225
Error	450	0.161	450	0.062	450	0.796	360	0.145

* Significant at .05 probability level.
** Significant at .01 probability level.

Appendix 11
Analysis of variance of ADG* of cows using shrunk weights for the six pasture systems for the years 1980 to 1983

Source	d.f.	Mean squares
Rep.	2	0.001
System (S)	5	0.272
Year (Y)	3	3.443**
Rep x System	10	0.065
Rep x Year	6	0.027
System x Year	15	0.108
Rep x System x Year	30	0.034
Error	333	0.082

** Significant at Probability = .01.
* ADG = Cow average daily gain, kg.

Appendix 12
Analysis of variance of calf gain in kg per hectare per animal using shrunk weights for the six pasture systems for the years 1980 to 1983

Source	d.f.	Mean squares
Rep.	2	14.24
System (S)	5	768.14**
Year (Y)	3	633.25**
Rep x System	10	10.69
Rep x Year	6	11.89
System x Year	15	16.93
Error	30	25.98

** Significantly different at 0.05 and 0.01 probability level.

Appendix 13
Orthogonal contrast among years for G/ha* using shrunk weights in the years 1980-1983.

	Treatment name and means					
	1980	1981	1982	1983		
	28	35	41	40	MS	F
Contrast						
1	+3	-1	-1	-1	1536.00	129.18**
2		+2	-1	-1	544.50	45.79**
3			+1	-1	9.00	0.756

* G/ha = Calf gain per hectare, kg/ha.
** Significantly different at 0.01 probability level.

Appendix 14
Analyses of variance of the gain per hectare of calves, 1980-1983.

	1980		1981		1982		1983	
	d.f.	Mean Squares	d.f.	Mean Squares	d.f.	Mean Squares	d.f.	Mean Squares
Period	4	18481.68**	4	33849.08**	4	21234.25**	4	21642.90**
System	5	276.59	5	474.19	5	1354.75	5	622.49
Syst. x Period	20	1168.85**	20	1561.29**	20	505.39	20	1525.46
Rep.	2	170.41	2	688.89	2	885.69	2	179.58
Rep. x Period	8	269.93	8	776.11	8	2011.67	8	795.39
Rep. x Syst.	10	234.83	10	337.89	10	1108.02	10	1371.88
Rep. x Syst. x Period	40	466.09	40	316.40	40	2899.29	40	711.87
Error	450	184.94	450	97.64	450	1491.74	360	509.33

** Significant at 0.01 probability level.

Appendix 15
Analyses of variance of cow G/ha+ using shrunk weights for the six pasture systems for the years 1980 to 1983

Source	d.f.	Mean squares
Rep.	2	4.94
System (S)	5	222.24**
Year (Y)	3	1237.9**
Rep x System	10	17.56*
Rep x Year	6	6.86
System x Year	15	24.80**
Error	30	7.65

* Significant at .05 probability level.
** Significant at 0.01 probability level.
\+ G/ha = Cow gain per hectare, kg/ha.

Appendix 16
Average initial and final weights (kg) of calves and average pasture sizes (ha) from 1980 to 1983. Values are averages of three reps.

Pasture System		1980	1981	1982	1983
1.	Initial wt.	41	52	65	61
	Final wt.	126	152	198	193
	Hectares	23.21	23.21	23.21	23.21
2.	Initial wt.	41	51	64	62
	Final wt.	135	167	198	201
	Hectares	19.02	19.02	19.02	19.02
3.	Initial wt.	42	52	66	60
	Final wt.	136	152	170	196
	Hectares	21.80	21.80	21.80	41.03
4.	Initial wt.	41	51	66	61
	Final wt.	126	152	171	201
	Hectares	18.72	18.72	18.72	18.72
5.	Initial wt.	41	51	64	61
	Final wt.	112	149	181	188
	Hectares	22.01	22.01	22.01	22.01
6.	Initial wt.	44	51	66	61
	Final wt.	118	153	175	197
	Hectares	18.96	18.96	18.96	18.96
Mean	Initial wt.	41	51	65	61
	Final wt.	126	154	182	196

Appendix 17
Average initial and final weights (kg) of cows
and average pasture size (ha) from 1980 to 1983.
Values are averages of three reps.

Pasture System		1980	1981	1982	1983
1.	Initial wt.	420	427	435	426
	Final wt.	407	1461	1482	1492
	Hectares	23.21	23.21	23.21	23.21
2.	Initial wt.	416	431	406	437
	Final wt.	1460	1485	1459	1508
	Hectares	19.02	19.02	19.02	19.02
3.	Initial wt.	430	437	429	439
	Final wt.	425	1490	1480	1508
	Hectares	21.80	21.80	21.80	21.80
4.	Initial wt.	426	450	434	437
	Final wt.	409	1495	1496	1511
	Hectares	18.72	18.72	18.72	18.72
5.	Initial wt.	419	411	428	450
	Final wt.	413	443	1475	1511
	Hectares	22.01	22.01	22.01	22.01
6.	Initial wt.	417	454	424	433
	Final wt.	425	466	460	499
	Hectares	18.96	18.96	18.96	18.96
Mean	Initial wt.	421	435	426	437
	Final wt.	423	473	475	505

Appendix 18
Quasi-F and degrees of freedom
formulas for testing system variance components

$$F\ (\text{System}) = \frac{M.S.S + M.S.SRY}{M.S.SY + M.S.SR}$$

$$\text{Num. df} = \frac{(M.S.S + M.S.SRY)^2}{\underset{S\ df}{(M.S.S)^2} + \underset{SRY\ df}{(M.S.SRY)^2}}$$

$$\text{Denom. df} = \frac{(M.S.SY + M.S.SR)^2}{\underset{SY\ df}{(M.S.SY)^2} + \underset{SR\ df}{(M.S.RS)^2}}$$

Documentation:

MS = Mean square
S = System
SRY = System x Rep x Year
SY = System x Year
SR = System x Rep

Appendix 19
Orthogonal contrast among systems for G/ha* of calves using shrunk weights

	Systems and means							
	1	2	3	4	5	6		
	36	47	34	42	25	30	MS	F
Contrast								
1	+1	+1	+1	+1	-2	-2	1710.2	159.98**
2	-1	-1	+1	+1			220.5	20.63**
3	+1	-1					1089.00	101.81**
4			+1	-1			576.00	53.88**
5					+1	-1	225.00	21.05**

* G/ha = Calves gain per hectare, kg/ha.
** Significantly different at 0.01 probability level.

Appendix 20
Orthogonal contrast among years for G/ha* using shrunk weights in the years 1980-1983.

	Years and means					
	1980	1981	1982	1983		
	0.28	12	18	17	MS	F
Contrast						
1	+3	-1	-1	-1	3996.12	495.06**
2		+2	-1	-1	363.00	52.92**
3			+1	-1	9.00	1.31

* G/ha = Cow gain per hectare, kg/ha.
** Significantly different at 0.01 probability level.

Appendix 21
Orthogonal contrast among systems for G/ha* of cows using shrunk weights.

	Systems and means							
	1	2	3	4	5	6		
	10	18	11	15	8	9	MS	F
Contrast								
1	+1	+1	+1	+1	-2	-2	600.00	34.17**
2	-1	-1	+1	+1			18.00	1.03
3	+1	-1					476.00	27.11**
4			+1	-1			144.00	8.20**
5					+1	-1	9.00	0.51

* G/ha = Cow gain per hectare, kg/ha.
** Significantly different at 0.01 probability level.

Appendix 22
Pasture size in hectares and pasture numbers for each rep and period of the six pasture systems.

Pasture System	Reps	Pasture Size/Pasture Number				
		Period 1	Period 2	Period 3	Period 4	Period 5
1	1	2.92/38	13.37/10	13.37/10	6.54/82A	6.54/82A
	2	3.77/37	13.37/11	13.37/11	6.53/82B	6.53/82B
	3	3.24/36	13.37/12	13.37/12	6.53/82C	6.53/82C
2	1	3.24/33	10.13/9	10.13/9	5.54/81C	5.54/81C
	2	3.20/34	10.13/6	10.13/6	5.54/81B	5.54/81B
	3	3.61/35	10.13/3	10.13/3	5.54/81A	5.54/81A
3*	1	3.28/48	13.37/14	13.37/14	3.28/48	3.28/48
	2	3.08/49	13.37/15	13.37/15	3.08/49	3.08/49
	3	3.40/54	13.37/16	13.37/16	3.40/54	3.40/54
4*	1	3.24/52	10.13/8	10.13/8	3.24/52	3.24/52
	2	3.03/53	10.13/1	10.13/1	3.03/53	3.03/53
	3	3.73/55	10.13/5	10.13/5	3.73/55	3.73/55
5	1	2.25/60	7.09/27	13.37/13	13.37/13	13.37/13
	2	2.29/61	6.20/25	13.37/17	13.37/18	13.37/17
	3	1.93/62	6.16/26	13.37/18	13.37/18	13.37/18
6	1	2.25/60	6.99/21	10.13/2	10.13/2	10.13/2
	2	2.29/61	6.99/22	10.13/4	10.13/4	10.13/4
	3	1.93/62	6.08/23	10.13/7	10.13/7	10.13/7

*Animals were placed on sudan grass (1.92 hectares for each rep) in Period 4 in 1980 and Period 5 in 1981.