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Utilization of Extended GrazingPeriods to Increase the Net Value of Cow/calf Enterprises (Project Description)

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Abstract

Cost associated with maintaining a cow herd during the winter months is a major expense to North Dakota cow/calf operations. A lion's share of this expense can be attributed to providing feed during nongrazing periods. Reducing the use of harvested forages, while maintaining cow perrformance, has been suggested as a means for lowering overall operating costs of beef production and increasing profitability of cow/calf enterprises.

This long term (5 yr) project proposes to investigate two mechanisms for reducing winter feeding costs of cow/calf operations in southwestern North Dakota. A nucleus of 48 pregnant beef cows will be maintained for use each year. The major component of the project focuses on evaluating stockpiled perennial forage and unharvested (standing) corn as late fall and early winter alternatives to drylot or confinement feeding of dry beef cows. Other aspects of the project will evaluate the economics of late season grazing using enterprise analysis, supplemental regimes for late season grazing and objective techniques for establishing body condition (energy reserves) of beef cows.

Introduction

Cost associated with winter feeding the cow herd is a major expense (approximately 38% of the total production costs; Hughes, 1995) associated with cow/calf operations in North Dakota. Procurement and feeding of harvested forages account for a large portion of this total expense. Reducing the use of harvested forages while maintaining cow performance could substantially lower overall operating costs of beef production and increase profitability of cow/calf enterprises. Lengthening the grazing period and/or reducing a reliance on harvested forage has been suggested as one method for reducing winter feeding costs.

Western North Dakota has a variety of forages that could be utilized by grazing cows in late fall and early winter when daily nutrient demands are relatively low. Two of the more noticeable of these are stockpiled perennial forage (ungrazed forage that is allowed to accumulate for support of grazing at a later date; Forage and Grazing Terminology Committee, 1992) and annually-seeded forages. However, a deficit of one or more dietary nutrients may limit the effective utilization of these forages by dry, pregnant cows. Providing small quantities of an appropriately formulated dietary supplement to animals consuming lower quality forages has been shown to be an effective mechanism for improving animal performance by enhancing forage utilization (digestibility and/or intake).

As grain producers contemplate the benefits of crop rotations, cow/calf operators can provide a viable, local market for alternative crops and co-products. This interaction, in many cases, would establish a floor price on a potential feedstuff that otherwise may have little marketable value. Besides being able to use fibrous residues, cows also offer the potential for using alternative grains and grain co-products as base ingredients in supplement formulations. Historically, a marriage between crop and beef producers has been mutually beneficial.

Data from other Great Plains states suggest that extending the grazing season, with appropriate supplementation regimes, is an effective mechanism for reducing the winter feeding costs and increasing profit potential of beef cow operations (Adams et al., 1994). Appropriately formulated supplements, utilizing locally available feedstuffs, seem key to the success of these endeavors. Data from the Northern Great Plains regarding the composition and availability of forage and grazing animal performance during the late fall and early winter period is limited. Data specific to North Dakota is severely limited. The generation and distribution of this type of information are essential if the cow/calf producers of North Dakota are to continue to operate in the increasingly competitive environment present in the beef industry today.

Objectives

1. Determine whether late fall/early winter grazing and supplementation is a feasible mechanism for reducing winter feeding costs and increasing the net value of the cow/calf enterprise.
2. Determine whether either energy or protein is the first-limiting nutrient for beef cows grazing stockpiled perennial forage in late fall and early winter grazing.
3. Determine whether type of corn seeded affects beef cow performance while grazing unharvested corn in late fall and early winter.

Literature Review

Profitability of the beef cattle industry depends in part on its ability to compete with other meat industries. To compete effectively, all segments of the beef industry must continue to lower costs per pound of meat produced (Barkema and Drabenstott, 1990; Adams et al., 1994). In most cases at least half the cost of production in cow/calf enterprises is feed (Hughes, 1995; Quinn, 1995) and standing or harvested forage represents most of this expense (Quinn, 1995). An Integrated Resource Management (IRM) project in Nebraska found that harvested forage costs range from 18 - 24% of the total cost of raising a calf to weaning (Rasby et al., 1989). Reducing the feeding of harvested forage, while maintaining or enhancing cow performance, could substantially increase the profitability of cow/calf producers and lower the overall costs of producing beef (Adams et al., 1994).

Winter feed, and in particular the amount of hay and other harvested feed used during the winter, is the largest contributor to the costs of feeder calf production (Rush, 1997). Cows possess the ability to utilize relatively poor quality forage during most of the winter when the nutrient demands of pregnancy are minimal in a nonlactating cow (Rush, 1997). However, indiscriminately cost-cutting within the winter feeding program is not the answer to increasing profitability in the cow/calf sector. Potential economic loss from thin cows is substantial (Torrell and Torrell, 1996), and body condition and productivity of a cow herd should not be allowed to deteriorate greatly from inadequate nutrition unless adequate time and resources are available to replace lost condition. Lalman (1997) illustrated the economics of utilizing least-cost ration balancing in formulating winter diets for beef cows. In a comparison of various supplements in combination with a poor quality forage to meet the needs of a 1100 pound beef cow during late pregnancy, there was a $15 per head difference between the most and the least expensive supplemental regime over a 90 day feeding period. In the same scenario with a medium quality forage, the difference in choice of a supplemental program was $27 per head.

Increasing the reliance on the cow, rather than machines, for forage harvesting is one method for reducing feed costs (D'Souza et al., 1990). Extending the grazing season on perennial forages or annually-seeded forage crops into late fall and early winter gives North Dakota producers a means for reducing their need for harvested forages. A Nebraska study (Adams et al., 1994) evaluated the impacts of cow/calf production on alternative forage treatments during winter and between calving and breeding. The study also considered the impact of these treatments on costs and returns to a cow/calf producer. Winter treatments included hay fed in confinement and supplemented grazing of winter range or sub-irrigated meadows. Spring treatments included hay feeding or grazing of sub irrigated meadows. In general, supplemented grazing of winter range from 15 November until 1 March resulted in an increase in net income of $30 per cow over a system that fed average quality hay. Forage systems also had different risk characteristics. Systems with reduced reliance on the use of hay during the winter exhibited less risk (less variation in net return). Apparently, increased variability in net return with the winter feeding of hay is due principally to the fact that feed costs are heavily dependent on hay price. Feed costs for the other systems relied more on the cost of supplement and land rental rates, which were less variable from year to year (Adams et al., 1994).

Many livestock producers in western North Dakota graze cattle into the late fall and winter months. Seasonal patterns of nutrient requirements of cattle typically do not match the seasonal patterns of forage quality and quantity provided by native range or improved pastures (Hart, 1991). Effective supplementation strategies are designed to provide dietary nutrients whose absence from the diet or presence in insufficient quantity is limiting animal productivity. Knowledge of dietary composition, intake and digestibility form the basis from which sound supplementation decisions are made. The identification of seasonal changes in these components should aid producers in determining composition, timing and amounts of supplementation necessary for livestock grazing rangeland.

Johnson (1996) evaluated seasonal changes in dietary composition, intake and digestibility of grazing cattle in southwestern North Dakota. Decreased digestibility and crude protein concentrations suggested that protein supplementation after the middle of November may be warranted in dry, pregnant cows. More specifically, late season changes in forage quality suggest the use of a high-quality, rumen-degradable protein supplement may have potential in late fall and winter grazing situations. A review of previous data from the region (Johnson, 1996) showed that protein supplementation may be beneficial as early as late July or early August.

Traditional feed grains (e.g., corn, and barley) tend to be readily available in North Dakota. In diets based upon lower quality forages, the amount of these feed grains required to balance a protein deficit tend to result in a decrease in forage intake and digestibility. Feedstuffs that contain a more favorable balance between protein and energy (.055 and .079 lb crude protein [CP]/Mcal of digestible energy [DE] for corn and barley, respectively; NRC, 1984) may be more desirable as late season supplements for grazing cattle. Grain processing co-products are currently available in North Dakota. Many of these co-products contain a higher proportion of protein per unit of energy than either corn or barley (.256, .154, .223, .302 and .135 lb CP/ Mcal DE for canola meal, corn gluten feed, safflower meal, sunflower meal and wheat middling, respectively; NRC, 1984). Several of these co-products have been evaluated as supplements for beef cattle in North Dakota.

Field pea is an alternative crop with growing popularity among crop producers in western North Dakota. Statewide acreage of field pea has increased from 1,600 acres in 1991 to approximately 68,000 acres harvested in 1997 (personal communication, ND Dry Pea and Lentil Assn.). Field pea has a favorable balance of protein and energy (.146 lb CP/Mcal DE; NRC, 1984). Field pea contains an energy level similar to that of barley (84 vs. 87% total digestible nutrients) with about twice the protein concentration (25.3 vs. 13.5%). The ruminal availability of field pea protein is relatively high (78%; Hickling, 1994). In backgrounding calf diets, animal performance was better when field pea was fed in a high forage diet than when it was fed in a high concentrate diet (Poland and Landblom, 1996). The nutritional characteristics of field pea suggest that it may make an excellent supplement for cattle grazing lower quality forages in late fall and early winter.

Using corn as a late fall and winter forage for beef cattle in North Dakota is not a new idea. Ford (1948) showed that nonlactating beef cows gained 2.2 lb/d while grazing unsupplemented corn during the months of October and November. Cows grazing corn plus a one pound supplement of soybean cake daily, averaged 2.4 lb/d. This level of nutrition would be very beneficial for thin cows in the fall. The additional body condition would help protect these cows from the severe cold normally associated with the months of December, January and February. Douglas and Langford (1959) reported that corn producing about twenty-five bushels per acre could support good gains in grazing yearling steers for seventy days. When unharvested corn is used to maintain gestating cows, we can expect better utilization and an extended grazing period. White (1973) harvested 2.65 ton of corn crop residue (wet basis) per acre before grazing and 2.05 ton/acre post grazing in a study involving sixty beef cows that grazed a 48-ha field for 111 days. This amounted to 23% utilization of the residue. Lamm et al. (1981) reported that beef cows grazing corn residue were selective in their grazing, selecting the grain, husks-leaves, cobs and stalks, in that order. Data for all fall-harvested plant parts had CP and IVOMD values of 8.8 and 72.0%. Nichols (1986) documented that the forage quality of corn stalks was higher than that of mature native range. Diet samples obtained from esophageal fistulated steers indicated that crude protein content of corn stalks averaged 8.7%, compared with 5% for native range. Digestability averaged 70.7% on corn stalks, compared with 46.3% for range. Lesoing et al.,(1996) reported that in Nebraska, beef cows grazing on corn residue for sixty days from December through February gained on average 0.63 pounds per head per day.

Allowing the cows to do the harvesting would reduce the labor and costs associated with feeding, eliminate or reduce manure handling and reduce the investment in harvesting and feeding equipment. Considerable stalk residue would remain on the field to act as a snow trap and to help reduce erosion. When cattle or sheep pasture corn fields, they deposit manure at the rate of approximately 0.65 tons per animal unit month (Ford, 1948). One serious drawback to grazing corn is the tendency of cattle to founder as a result of too much energy or grain in the diet. Providing adequate water and wind protection from cold weather and blizzards is another concern. There could also be a problem with the invasion of the corn fields by large numbers of migrating ducks and geese (personal experience).

Modern corn production using no-till planting in early May (along with good seed, fertilizer levels based upon soil tests, and excellent weed control) can result in excellent stands of corn with high yield potential, based upon the last several years of corn production in the Dickinson area. Producers planning to graze corn in late fall may select corn varieties that have various maturity ranges, that have flinty, dented or waxy kernels, or that have higher sugar contents. Modern corn varieties have resistance to root disease and have less trouble with lodging. They also develop ears high off the ground. Long term records (forty-five years) at the Dickinson Experiment Station show that wheat yields following clean corn were only 2.5 bu/a less than yields of wheat grown on summer fallow (Wiidakas et al., 1954).

Materials and Methods

A spring (mid May to early June) calving cow herd, forty-eight head, at the Dickinson Research Extension Center will serve as a nucleus to support this project. The cows will be managed in drylot from 1 February through late April. The cows will be relocated to predominately crested wheatgrass (*Agropyron desertorum*) pastures in late April and grazed until early June. They will calve extensively on pasture between May and early June. In early June, forty-eight cows with calves at least seven days old will be moved to a native range pasture and managed in replicated (n=4) pastures using a seasonlong grazing system in each pasture. The groups of cows will rotate monthly among pastures to reduce any pasture effect on individual cows. Estrus will be synchronized and the cows inseminated by time breeding during the second week in August (approximately 8 August) each year of the study. The cows will then be exposed to clean up bulls for twenty-eight days. The cows and calves will continue to graze native range until weaning. If cows need to be moved prematurely, they will be housed in drylot or in an alternative pasture. The calves will be weaned on or about 15 October and moved to drylot at the DREC ranch headquarters. Following weaning in years 2 and 3, the cow herd will be allotted into six groups with 8 hd per group. These groups will then be randomly assigned to one of three wintering systems (Exp. 1). In years 4 and 5, the cow herd will be split into two, 24-head groups. One group of cows will be moved on to a stockpiled winter pasture (pasture where following winter grazing subsequent forage growth was allowed to accumulate in the absence of grazing). The other group will move to annually-seeded crop land. Groups will graze either perennial forage(Exp. 2) or unharvested corn fields (Exp. 3) until late January. Both groups will move into drylot when their respective grazing period ends.

Wintering systems (Objective 1). In each of 2 years (fall 1998 - spring 2000), three beef cow wintering systems will be evaluated. Groups of cows (8 hd/group, 2 groups/system) will be managed on stockpiled perennial forage, unharvested (standing) corn or in drylot. The cows assigned to stockpiled perennial forage will graze until late January. Yearly stocking rates will be dependent upon initial herbage mass in October. The cows will be fed a commercial feed supplement formulated for use with cattle grazing late-season, native range. Composition of the supplement and amount of supplement fed per day will depend upon the supplier of the supplement. The same supplier and brand of supplement will be used in both years. The cows grazing perennial forage in a group-feeding situation within replicated pastures will be supplemented. The cows assigned to unharvested corn will graze fields of standing corn without supplement. Yearly stocking rates for the cows grazing the corn fields will depend upon the amount of forage available in October for grazing. Those cows assigned to corn grazing will also graze until late January, if possible. The cows managed in drylot (controls) will be fed and housed in replicated feedlot pens at Ranch headquarters. Weather data (average, previous and current), initial cow weight and body condition, desired final body condition and days to calving will be used to calculate nutrient requirements of a dry, pregnant, beef cow fed in confinement (NRC, 1996). The cows will be fed to meet or exceed daily nutrient requirements with diets based upon hay, corn silage and supplement. Within a year, cows in the 2 grazing systems will be moved into a drylot situation as their respective grazing periods terminate. While in drylot, cows will be managed the same as the drylot (control) treatment. Starting February 1, the last trimester, cattle will be fed based upon their present body conditon and expected performance.

Stockpiled winter pasture (Objective 2). In each of 2 years (fall 2000 - spring 2002), twenty-four cows will be managed on a single winter pasture from mid October until late January. Yearly stocking rates will be dependent upon initial herbage mass and desired length of grazing. Within each year, cows will be allotted into 4 supplemental treatment groups. Each group will consist of 6 dry, pregnant cows. Treatments will include an unsupplemented control and 3 supplemented groups. Supplemental treatments will be formulated to supply additional energy or rumen-degradable protein. Supplemental formulations will be based upon combinations of barley and field pea. A sole barley treatment will represent an energy supplement, while a sole field pea treatment will represent a rumen-degradable protein source. An additional treatment of barley and pea with appropriate supplement will also be fed. Supplements will be available daily to individual animals, with supplemental intake limited by using a computer-controlled automatic feeder wagon (Cyber feeder, Sheyenne Advanced Feeding Systems, Cooperstown, ND; Nelson and Ringwall, 1996). Use of the initial set of supplements will be replicated in 2 years.

Crop land grazing (Objective 3). In each of 2 years (fall 2000 - spring 2002), fields of 2 types of corn will be grown and fenced into replicated pastures (6 pregnant cows per pasture, 2 pastures per corn type). The type of corn planted will be a late-maturing (90 day), high-sugar corn and a double-cross hybrid dent corn (80 day). The hybrid dent corn is expected to yield an average 1.77 tons of dry matter per acre (Cross and Berglund, 1997). At a conservative use rate of 45% and a cow feed intake rate of twenty-two lb/day of dry matter (NRC, 1984), an acre of corn should provide a 1,300 lb pregnant cow in the middle third of pregnancy with approximately 72 days of grazing. Moderate stocking rates (based upon herbage available and desired grazing days) will be used. Herbage availability, use and composition plus animal data will be collected.

Net Value Enterprise Analysis (Objective 1). A minimum of 4 pairs of cow/calf operations from southwestern North Dakota will be part of a complete enterprise analysis. A pair of operations will include two operations from the same general area. One member of the pair will be chosen to represent an operation that uses late-season grazing of native range. The other member of the pair will be chosen to represent an operation that removes cows from native range in mid fall. An enterprise analysis (NCA, 1992) will provide a standardized summary of the production and economic characteristics of each operation. Three complete years of data collection from each operation will be recorded. Compilation of data and averaging across operations and years within grazing type will allow a qualitative comparison of the production and economic characteristics of late season grazing of native range with beef cattle in southwestern North Dakota. Calculated benchmark (average) values will then be used to construct an economic analysis of wintering systems using production data generated in

Exp. 1, 2 and 3.

Data/sample collection. On each system, the cows will be weighed on 14-day intervals throughout the course of the winter. Before weighing, the cows will have access to feed but water will be with held for approximately eighteen hours to help stabilize their digestive fill. On each weigh day, body condition scores (9-point scale) and backfat (LEAN-MEATER, type LM-8; Renco Corporation, Minneapolis, Minnesota) measurements will be recorded for each cow. Body condition scores will be estimated by two observers and an average score calculated. The same scorers will be used to increase consistency in body condition scoring between weigh days. Fetal development in cows will be monitored on weigh days using real-time ultrasound technologies (Micro Imager 1000; Ausonics, Sidney, Australia). Other animal data to be recorded will include days to first postpartum heat, response to synchronization and artificial insemination, and subsequent breeding performance.

Herbage available for grazing will be sampled at 28-d intervals to detect changes in dry matter yield and composition (botanical and chemical). In addition, annual exclosures will be established in each pasture to allow sampling of ungrazed herbage. Chemical composition of herbage (available for grazing and ungrazed) will include protein (crude; rumen degradable and acid-insoluble), acid and neutral detergent fiber, calcium, phosphorus, magnesium, sulfur, copper, iron, molybdenum and zinc. Chemical composition will be determined by an independent laboratory.

All feed deliveries (supplement, hay and silage) and refusals for respective treatment groups within year and experiment will be recorded. Ration formulations and daily feed deliveries will be determined as described in Exp. 1. Feed recording will begin at weaning in each year and end as cattle move to spring calving pastures. After moving to pasture, all cows will be managed similarly until weaning the next fall.

Determination of end of grazing period. Grazing periods will end based on 1 of 3 criteria. An initial termination date will be set at the beginning of each grazing trial. Each grazing trial has a desired grazing length (mid October to late January). However, grazing within a treatment group will end earlier if the average body condition score of the group falls below four or if greater than 1/3 of the cows in the group has a body condition score less than 4 on any weigh day. At the end of grazing, all animals within a treatment group will be moved to drylot at the DREC ranch headquarters. Cows will remain in this facility until grazing commences the following spring. Ration formulation and feed delivery to each treatment group while in drylot will be based upon a targeted body condition. A minimum body condition score of 5.0 at calving for all cows is desired (Short et al., 1990; Lemenager et al., 1992). Cattle will be split by those less than body condition score 5 and those 5 or greater and managed in replicated groups to achieve condition scores of 5 by calving. This procedure most likely will mask potential treatment effects of wintering treatments on subsequent cow and calf performance; thus, it will be the response variables associated with the magnitude and cost of supplying nutrients within a targeted calving-condition system that should measure treatment differences.

Statistical analysis. Animal data collected on weigh days (e.g., body weight, body condition score, backfat measurement, cumulative feed deliveries and refusals) and herbage data will be analyzed utilizing a split-plot in time arrangement in sample collection. Within experiment, whole plots will be arranged using a completely random design, blocked across years. Treatment will represent a fixed effect within the whole plot. Replicates of cow groups within year and treatment combinations will serve as the experimental unit in the analysis of the whole plot for Exp. 1 and 3. Animal within year and treatment combinations will serve as the experimental unit in the analysis of the whole plot for Exp. 2. Sampling date will be treated as a fixed effect and be used as the split-plot factor. The framework for an analysis of variance is presented in Table 1. The framework identifies sources of variation, fixed/random effects, degrees of freedom and error terms. If individual initial error terms have f-test probability values that exceed 0.2, pooling of error terms will be considered. Significant (P<.10) treatment effects will be separated using a Bonferroni's t-test. Significant effects involving year will be described using polynomial contrasts.

Probable Duration: 5 years, 1997 - 2002.

Literature Cited

Adams, D.C., and R.T. Clark, S.S. Coady, J.B. Lamb and M.K. Nielsen. 1994. Extended grazing systems for improving economic returns from Nebraska sandhills cow/calf operations. J. Range Manage. 47:258-263.

Barkema, A.D. and M. Drabenstott. 1990. A crossroads for the cattle industry. Econ. Rev. Federal Reserve Bank of Kansas City. Nov/Dec. 47-66.

Cross, H.Z. and D.R.Berglund. 1997. North Dakota Hybrid Corn Performance Testing 1996, 58th Edition, NDSU Extension Service. Douglas, R. and L. Langford. 1960. Corn Pasturing By Yearling Steers. North Dakota Farm Research, Vol. 21, No. 4, March-April, 1960, pp 21-22.

D'Souza, G.E., and E.W. Marshall, W.B. Bryan and E.C. Prigge. 1990. Economics of extended grazing systems. Amer. J. Alternative Agr. 5:120-125.

Forage and Grazing Terminology Committee. 1992. Terminology for grazing lands and grazing animals. J. Prod. Ag. 5:191-201. Ford, Kenneth D., 1948. Pasturing of mature corn with cows and young steers. Bimonthly Bulletin, Volume X, No. 5, May-June. Hart, R.H. 1991. Developing strategies for integrating forage parameters to meet the nutritional needs of grazing livestock. *In:* Proceedings, 2nd Grazing Livestock Nutrition Conference. pp 64-82. Steamboat Springs, CO.

Hickling, D. 1994. Canadian peas: feed industry guide. Canadian Special Crops Assn. (Winnipeg, Manitoba) and Western Canada Pulse Growers Assn. (Regina, Saskatchewan).

Hughes, H. 1995. IRM-FARMS Databank, 1994 herds. Dept. Ag. Econ., North Dakota State University.

Johnson, J. 1996. Influence of season on dietary composition, intake and digestion by beef steers grazing mixed-grass prairie in western North Dakota. M.S. thesis. North Dakota State University, Fargo.

Lamm, W.D. and J.K. Ward. 1981. Compositional Changes In Corn Crop Residues Grazed By Gestating Beef Cows. Journal of Animal Science, Vol. 52, No. 5, pp 954-958.

Lalman, D. 1997. Evaluating alternative winter supplements for beef cattle. *In:* Producer Education Seminars, an adjunct program to 1997 cattlemen's college. National Cattlemen's Beef Assn.

Lemenager, R.P., and R.N. Funston and G.E. Moss. 1992. Manipulating nutrition to enhance (optimize) reproduction. *In:* Proceedings, 2nd Grazing Livestock Nutrition Conference. pp 13-31. Steamboat Springs, CO.

Lesoing, G., and D. Shain, T. Klopfenstein, J. Gosey, M. Schroeder, 1996. Effects of Sorghum and Cornstalk Grazing on Crop Production, 1996 Nebraska Beef Cattle Report. pp40-43.

NCA. 1992. NCA-IRM standardized performance analysis (NCA-IRM-SPA™): Guidelines for production and financial performance analysis for the cow-calf producer: Cow-calf SPA™. Extension service - USDA, Washington D.C. Nelson, J.L. and K.Ringwall. 1996. Portable, electronic, individual feeding system for cattle on pasture. Final project report. Agricultural Products Utilization Commission, Bismarck, ND.

Nichols, J.T., 1986, Opportunistic Use of Complementary Forages, Proceedings, The Range Management Symposium, November 5-7, 1986, North Platte, Nebraska.

NRC. 1984. Nutrient requirements of beef cattle (6th Ed.). National Academy of Science. National Research Council, Washington, DC.

NRC. 1996. Nutrient requirements of beef cattle (7th Ed.). National Academy of Science. National Research Council, Washington, DC.

Poland, W.W. and D.G. Landblom. 1996. Feeding value of field pea and hulless oat in growing calf diets. *In:* North Dakota Cow/Calf Conference and Beef Cattle and Range Research Report. Bismarck, ND.

Quinn, 1995. Using nutrient values of range and harvested forage can increase profit. *In:* Proceedings, International Beef Symposium. pp 226-240. Great Falls, MT.

Rasby, R., M. Frazier, G. Duetscher, I. Rush, T. Mader, J. Gosey and D. Hudson. 1989. Integrated resource management. P. 1-9. *In:* 1990 Beef Cattleman Roundup. Nebraska Cooperative Extension. Univ. Nebraska-Lincoln, Inst. Agr. And Natur. Resources, WCC 90-1, Lincoln, NB.

Rush, I. 1997. Winter feeding to get the most from forages. *In:* Producer Education Seminars, an adjunct program to 1997 cattlemen's college. National Cattlemen's Beef Assn.

Torrell, L.A. and R.C. Torrell. 1996. Evaluating the economics of supplementation practices. *In:* Proceedings, 3rd Grazing Livestock

Nutrition Conference. pp. 62-71. Custer, SD.

White, G.C., 1973. Crop residue utilization and nitrogen supplementation for beef cows. MS Thesis, University of Nebrska, Lincoln, Nebraska.

Wiidakas, W., and R.B. Widdifield, R. Douglas, and T.J. Conlon. 1954. Grow more corn for silage, feed reserves and weed control. Bimonthly Bulletin, Volume XVI, No. 4, March-April.

Table 1. Example analysis of variance for animal data. Includes sources of variation, fixed/random effects, degrees of freedom and error terms.

No.	Source of variation	Fixed or random	Error terms	
			Initial	Pooled[a]
1.	Year (Y)	R	-	-
2.	Treatment (T)	F	3	3+4
3.	Y*T	R	4	-
4.	Animal (Y*T)	R	-	-
5.	Time (t)	F	6	6+8, 6+8+9
6.	t*Y	R	9	-
7.	t*T	F	8	8+9
8.	t*Y*T	R	9	-
9.	Residual	R	-	-

[a] If initial error terms have f-test probability values that exceed 0.2, pooling of error terms will be

considered.

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