Pasture and Forage Costs-Returns of Twelve-Month Management Strategies for Range Cows

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Introduction

The pasture-forage factors that contribute to high beef production costs in the Northern Plains need to be identified before the profit margin can be improved. Achieving this determination requires that management practices be scientifically evaluated for pasture and harvested-forage costs, which constitute the greatest portion of the total annual production costs for a beef cow and calf. Because the daily requirements for cows differ with production period, proper evaluation of management strategies comprises two steps: evaluation of pasture and forage costs for each production period and evaluation of the management strategies for livestock production periods as components within a complete 12-month pasture-forage management system. Effectively reducing livestock production costs for range cows by reducing 12-month pasture and harvested-forage costs during all of the cows' production periods requires an understanding of the production costs of common traditional practices and the costs of readily available alternative management practices.

This study evaluated several 12-month pasture-forage management strategies to determine the pasture-forage costs and returns for range cows during the cows' production periods. The 12-month pasture-forage management strategies were identified by the type of grazing system used during the native rangeland segment: 12.0-month repeated seasonal, 6.0-month seasonlong, 4.5-month seasonlong, 4.0-month deferred, and 4.5-month twice-over rotation. The management strategy costs evaluated were pasture or land rent values per acre; production costs per acre; costs per unit of forage dry matter; costs per unit of nutrient; land area per animal unit; forage feed costs per day, per month, or per production period; and costs per pound of calf weight gain.

Procedure

This study was conducted at the NDSU Dickinson Research Extension Center, located in western North Dakota. The native rangeland vegetation is the Wheatgrass-Needlegrass Type (Barker and Whitman 1988) of the mixed grass prairie. The dominant native range species are western wheatgrass, needle and thread, blue grama, and threadleaved sedge. Crested wheatgrass and Altai wildrye pastures were seeded as monocultures, but a small assortment of forb and other grass species developed as minor components. Pasture-forage costs and returns were evaluated from cow and calf weight performance data collected on grazing management treatments involved in pasture research projects conducted between 1983 and 1998 and from forage production data collected on harvested-forage types between 1995 and 1999. Native rangeland herbage weight data used in the determination of stocking rate for the 12.0-month native range grazing strategy were collected monthly from ungrazed plots. The research data collected during severe water stress or drought periods were not included in this study.

Commercial Hereford and Angus-Hereford cows with Charolais-sired calves were allocated to grazing treatments each spring. Individual animals were weighed on and off each treatment and at biweekly or monthly intervals during the grazing season. The livestock weight data collected on the grazing treatments were used to determine cow and calf weight performance. Range cow daily nutritional requirements, which change with cow size, level of milk production, and production period, were taken from NRC (1996). Dry matter and crude protein requirements were determined for cows with an average weight of 1200 pounds. An assumed price of $0.70 per pound was used to determine the economic value of calf accumulated weight.

Forage costs for harvested-forage types used as feed for range cows were evaluated as components of 12-month management systems. Forage dry matter yield per acre and percent crude protein data for perennial domesticated grass hay and annual cereal and annual legume hays were taken from a previous study (Manske and Carr 2000). Percent crude protein data for native range grasses were taken from Whitman et al. (1951) and Manske (1999 a, b). Supplemental crude protein was provided as 20% crude protein range cake, at a cost of $120.00 per ton. Supplemental forage dry matter was provided as roughage, at a cost of $35.00 per ton.

The pasture rent value of $8.76 per acre was used to determine costs for native rangeland and domesticated grass pastures. One treatment of crested wheatgrass was fertilized annually with 50 pounds of nitrogen per acre, at an average cost of $12.50 per acre. The value of $2.00 per acre was used for cropland aftermath grazing costs: grazing on cropland aftermath is not without cost even if most of the costs are charged to the harvested crop. Land rent values of $22.07 per acre for cropland and $14.22 per acre for domesticated grass hayland were used in the determination of forage production costs for the harvested forages.

Pasture and forage costs of feed to meet livestock dry matter and crude protein requirements were determined during this study. Production costs per acre were determined by adding average land rent per acre, custom farm work rates, seed costs per acre, and baling costs at per half ton rates. Costs per ton of forage dry matter (DM) were determined by dividing production costs per acre by pounds of forage dry matter yield per acre and multiplying the quotient by 2000 pounds. Costs per pound of crude protein (CP) were determined in two stages: first, pounds of forage dry matter per acre were multiplied by percentage of forage crude protein to derive pounds of crude protein per acre; then, production costs per acre were divided by pounds of crude protein per acre. Pasture land area per animal unit per month was determined in two stages: first, pounds of forage dry matter per acre were divided by pounds of forage dry matter required per animal unit per day to derive number of grazing days per acre; then, the average number of days per month was divided by the number of grazing days per acre. Harvested-forage land area per animal unit per month or per production period was determined in two stages: first, pounds of crude protein required per animal per day during a production period were divided by percentage of crude protein of forage type to derive pounds of forage dry matter to provide as feed per animal unit per day; then, pounds of forage dry matter to feed per day were divided by pounds of forage dry matter per acre, and the quotient was multiplied by 30 days per month, 30.5 days per month, or the number of days per production period. Forage feed costs per animal per day (D), per month (Mo), or per production period (PP) were determined in three stages: first, production costs per acre were divided by pounds of forage dry matter per acre, and that quotient was divided by percentage of forage crude protein to derive cost per pound of crude protein; next, the cost per pound of crude protein was multiplied by pounds of crude protein required per animal per day during a production period; then, the feed costs per day were multiplied by 30 days per month, 30.5 days per month, or the number of days per production period. Costs per pound of calf weight gain were determined in two stages: first, accumulated calf weight gain was determined by subtracting calf live weight at the beginning of a growth period from calf live weight at the end of a growth period; then, total pasture costs or forage production costs for a calf growth period were divided by the accumulated calf weight for the growth period.

Management Strategies

The descriptions of the 12-month pasture-forage management strategies begin with the dry gestation production period on the day after the previous calf was weaned and progress to the third trimester production period and the birth of a calf, then through early lactation, spring lactation, summer lactation, and fall lactation periods, until the weaning of the calf. Harvested forages included in the 12-month management strategies were cut by swathing and were then rolled into large round bales. Mature crested wheatgrass hay was cut at a mature plant stage. Forage barley hay was cut at the milk stage.

The 12.0-month repeated seasonal (12.0 M RS) management strategy was developed from herbage biomass data collected monthly from ungrazed plots. This strategy was evaluated as a sequence of separate native range pastures grazed at proper stocking rates, with each pasture grazed repeatedly during one livestock production period, at the same time (season) each consecutive year, and not grazed during any other production periods. A native range pasture was grazed for 32 days from mid November to mid December, during the dry gestation production period, at a stocking rate of 4.00 acres per cow per month, and supplemental range cake was provided. A native range pasture was grazed for 90 days from mid December to mid March, during the third trimester production period, at a stocking rate of 4.97 acres per cow per month, and supplemental range cake was provided. The calves were born in mid March. A native range pasture was grazed for 45 days from mid March to late April, during the early lactation production period, at a stocking rate of 6.48 acres per cow-calf pair per month, and supplemental range cake was provided. A native range pasture was grazed for 31 days in May, during the spring lactation period, at a stocking rate of 4.62 acres per cow-calf pair per month. A native range pasture was grazed for 137 days from early June to mid October, during the summer lactation period, at a stocking rate of 2.52 acres per cow-calf pair per month. A native range pasture was grazed for 15 days from mid to late October, during the early portion of the fall lactation period, at a stocking rate of 4.20 acres per cow-calf pair per month, and supplemental range cake was provided. A native range pasture was grazed for 15 days from early to mid November, during the late portion of the fall lactation period, at a stocking rate of 5.00 acres per cow-calf pair per month, and supplemental range cake was provided. The calves were weaned in mid November.

Cows on the 6.0-month seasonlong (6.0 M SL) management strategy were fed a harvested-forage ration of mature crested wheatgrass hay and roughage for 32 days from mid November to mid December, during the dry gestation production period. Cows were fed a harvested-forage ration of mature crested wheatgrass hay and range cake for 90 days from mid December to mid March, during the third trimester production period. The calves were born in mid March. Cows were fed a balanced dry lot ration of crested wheatgrass, alfalfa, and corn silage for 60 days from mid March to mid May, during the early lactation production period. The grazing portion of the 6.0-month seasonlong management strategy started in mid May. Livestock were moved to a single native range pasture stocked at 4.04 acres per cow-calf pair per month. Livestock grazed on the pasture for 183 days, until mid November, when the calves were weaned.

Cows on the 4.5-month seasonlong (4.5 M SL) management strategy were fed a harvested-forage ration of mature crested wheatgrass hay and roughage for 32 days from mid November to mid December, during the dry gestation production period. Cows were fed a harvested-forage ration of mature crested wheatgrass hay and range cake for 90 days from mid December to mid March, during the third trimester production period. The calves were born in mid March. Animals were fed a balanced dry lot ration of crested wheatgrass, alfalfa, and corn silage for 45 days from mid March to late April, during the early lactation production period. The grazing portion of the 4.5-month seasonlong management strategy started in early May. For the first 31 days livestock grazed an unfertilized crested wheatgrass pasture stocked at 1.82 acres per cow-calf pair per month. In early June livestock were moved to one native range pasture stocked at 2.86 acres per cow-calf pair per month. Livestock grazed on this pasture for 137 days, until mid October, when they were moved to cropland aftermath stocked at 6.63 acres per cow-calf pair per month. Livestock grazed cropland aftermath pastures until mid November, when the calves were weaned.

Cows on the 4.0-month deferred (4.0 M Def) management strategy grazed cropland aftermath at a stocking rate of 6.63 acres per cow per month for 32 days from mid November to mid December, during the dry gestation production period. Cows were fed a harvested-forage ration of mature crested wheatgrass hay and range cake for 90 days from mid December to mid March, during the third trimester production period. The calves were born in mid March. Cows were fed a balanced dry lot ration of crested wheatgrass, alfalfa, and corn silage for 45 days from mid March to late April, during the early lactation production period. The grazing portion of the 4.0-month deferred management strategy started in early May. For the first 76 days livestock grazed an unfertilized crested wheatgrass pasture stocked at 1.67 acres per cow-calf pair per month. In mid July the livestock were moved to one native range pasture stocked at 2.22 acres per cow-calf pair per month. Livestock grazed on this pasture for 122 days, until mid November, when the calves were weaned.

Cows on the 4.5-month twice-over rotation (4.5 M TOR) management strategy were fed a harvested-forage ration of early cut forage barley hay and roughage for 32 days from mid November to mid December, during the dry gestation production period. Cows were fed a harvested-forage ration of early cut forage barley hay and roughage for 90 days from mid December to mid March, during the third trimester production period. The calves were born in mid March. Cows were fed a harvested-forage ration of early cut forage barley hay and roughage for 45 days from mid March to late April, during the early lactation production period. The grazing portion of the 4.5-month twice-over rotation management strategy started in early May. For the first 31 days livestock grazed a fertilized (50 lbs N/acre on 1 April) crested wheatgrass pasture stocked at 0.75 acres per cow-calf pair per month. The livestock were then moved to one of three native range pastures stocked at 2.04 acres per cow-calf pair per month. Livestock remained on native range for 137 days, grazing each pasture for two periods, one 15-day period between 1 June and 15 July (when lead tillers of grasses were between the third-leaf stage and flowering stage) and one 30-day period after 15 July (after secondary tillers of grasses reached the third-leaf stage) and prior to mid October. The first pasture grazed in the sequence was the last pasture grazed the previous year. In mid October the livestock were moved to an Altai wildrye pasture stocked at 1.39 acres per cow-calf pair per month. Livestock grazed on this pasture for 30 days, until mid November, when the calves were weaned.

Results

Twelve-month pasture-forage costs for each management strategy are shown in tables 1-5. Pasture-forage returns for management strategies are shown in tables 6-7. Pasture-forage feed costs per production period for management strategies are shown in table 8. Costs per pound of calf weight for management strategies are shown in table 9.

12.0-month repeated seasonal

The 12.0-month repeated seasonal management strategy was developed from monthly herbage biomass data collected from ungrazed plots. It was evaluated as a system of separate native range pastures grazed at proper stocking rates, with each pasture grazed repeatedly during one livestock production period, at the same time each year. Calf weight and performance on this management strategy were estimated based on 1.80 lbs average daily gain and 95 lbs birth weight.

Cows grazed a reserved native range pasture during the dry gestation production period. Native range pasture during the fall dormancy period has a crude protein content of around 4.8%. Late-season native range forage had pasture rent value or production costs of $8.76 per acre, forage dry matter costs of $97.33 per ton, and crude protein costs of $1.01 per pound. A cow grazing during the dry gestation production period required 4.00 acres of native range pasture per month, or 4.27 acres per period, at a cost of $1.17 per day, $35.10 per month, or $37.44 for the 32-day period. The crude protein content of mature native range forage is below the requirements of a cow in the dry gestation stage, and crude protein would need to be supplemented at 0.34 lbs per day, or 10.2 lbs per month per cow, at a cost of $3.26 per period. Total feed cost was $40.70, or $1.27 per day, during the dry gestation period.

Cows grazed a reserved native range pasture during the third trimester production period. Native range pasture during the fall and winter dormancy period has a crude protein content of around 4.8%. Late-season native range forage had production costs of $8.76 per acre, forage dry matter costs of $120.83 per ton, and crude protein costs of $1.26 per pound. A cow grazing during the third trimester required 4.97 acres of native range pasture per month, or 14.90 acres per period, at a cost of $1.45 per day, $43.50 per month, or $130.50 for the 90-day production period. The crude protein content of mature native range forage is below the requirements of a cow in the third trimester, and crude protein would need to be supplemented at 0.72 lbs per cow per day, or 64.8 lbs per cow for the 90-day period, at a cost of $19.44 per period. Total feed cost was $149.94, or $1.67 per day, during the third trimester period. The calves were born in mid March, at an average weight of 95 pounds. The cost per pound of calf birth weight was $1.58.

Cows grazed a reserved native range pasture during the early lactation period. During early spring, forage on native range pasture has a crude protein content of around 9.2%. Early spring native range forage had production costs of $8.76 per acre, forage dry matter costs of $140.16 per ton, and crude protein costs of $0.76 per pound. A cow grazing during the early lactation period required 6.48 acres of native range pasture per month and 9.72 acres per period, at a cost of $1.89 per day, $56.70 per month, or $85.05 for the 45-day period. The crude protein content of early spring native range forage is below the requirements of a cow during early lactation, and crude protein would need to be supplemented at 0.25 lbs per cow per day, or 7.5 lbs per cow per month, at a cost of $3.38 per period. Total feed cost was $88.43, or $1.97 per day, during the early lactation period. The cost of calf weight gain was $1.09 per pound.

Cows grazed a native range pasture for 31 days in May, during the spring lactation period. Spring native range forage has a crude protein content of around 16.3%. Spring native range forage had production costs of $8.76 per acre, forage dry matter costs of $89.85 per ton, and crude protein costs of $0.28 per pound. A cow grazing during the spring lactation period required 4.62 acres per month and 4.77 acres per period, at a cost of $1.35 per day, or $40.50 per month. Total feed cost was $41.85 during the spring lactation period.

Cows grazed a native range pasture for 137 days, during the summer lactation period. Native range forage has a crude protein content of around 9.6% during mid summer. The crude protein content on native range grasses decreases after mid summer and is below the requirements of a lactating cow by early August. Summer native range forage had production costs of $8.76 per acre, forage dry matter costs of $48.26 per ton, and crude protein costs of $0.25 per pound. A cow grazing during the summer lactation period required 2.52 acres per month, or 11.32 acres per period, at a cost of $0.72 per day, or $21.60 per month. Total feed cost was $98.64 during the summer lactation period. The cost of calf weight gain was $0.54 per pound.

Cows grazed reserved native range pastures during the fall lactation period. The costs of grazing native rangeland during the fall were determined separately for the early and late portions of the period. The costs of grazing native rangeland during the fall are considerably higher than the costs of grazing native rangeland during the summer. The weight of the herbage on fall pastures is only about 40% to 60% of the mid summer herbage weight on grasslands that have had no grazing all growing season. The crude protein content of fall herbage is around 4.8%, about half the content of mid summer herbage. Fall-grazed native range pasture forage had production costs of $8.76 per acre; forage dry matter costs of $80.37 and $97.33 per ton during early and late fall, respectively; and crude protein costs of $0.34 and $1.01 per pound during early and late fall, respectively. A lactating cow grazing during the fall required 4.20 acres and 5.00 acres per month, at a cost of $36.30 and $43.80 per month, during early and late fall, respectively. The crude protein content of mature native range forage is below the requirements of a lactating cow during the fall, and crude protein would need to be supplemented at 1.21 lbs per cow per day, at a cost of $10.90 per 30-day period. Total feed cost was $23.85, or $1.59 per day, during the early fall lactation period and was $27.35, or $1.82 per day, during the late fall lactation period.

Total feed costs for the 12.0-month repeated seasonal management strategy were $470.76 for a 12-month production period. Calf weaning weight was 532.40 pounds. When calf weaning weight was assumed to have a value of $0.70 per pound, the gross return was $372.68 per calf, and the net returns after 12-month pasture-forage costs were a loss of $98.08 per cow-calf pair and a loss of $1.98 per acre. Each pound of calf weaning weight cost $0.88 for the 12-month production period.

6.0-month seasonlong

Cows on the 6.0-month seasonlong management strategy were fed mature crested wheatgrass hay for 32 days, during the dry gestation production period. Crested wheatgrass cut late, at a mature plant stage, has a crude protein content of around 6.4%. This low-quality perennial grass hay had production costs of $28.11 per acre, forage dry matter costs of $34.80 per ton, and crude protein costs of $0.28 per pound. Late-cut crested wheatgrass hay would be fed at 23.4 lbs DM/day to provide 1.5 lbs CP/day. An additional 0.6 lbs of roughage per day, at a cost of $0.34 per period, would need to be provided. Production of late-cut crested wheatgrass hay to feed a cow during the dry gestation production period required 0.44 acres per month and cost $0.41 per day, $12.32 per month, or $13.12 per period. Total feed cost was $13.46, or $0.42 per day, during the dry gestation period.

Cows on the 6.0-month seasonlong strategy were fed mature crested wheatgrass hay during the third trimester production period. Late-cut mature crested wheatgrass hay would need to be fed at 29.7 lbs DM/day to provide 1.9 lbs CP/day. The nutrient content of mature crested wheatgrass hay is below the dietary requirements of a cow in the third trimester. An additional 0.33 lbs of crude protein per day, at a cost of $8.91 per period, would need to be provided when mature crested wheatgrass hay is fed at the dry matter requirement of 24 lbs DM/day. Production of mature crested wheatgrass hay to feed a cow in the third trimester required 0.45 acres per month and cost $0.52 per day, $15.60 per month, or $46.80 for the 90-day production period. Total feed cost was $55.71, or $0.62 per day, during the third trimester period. The calves were born in mid March, at an average weight of 95 pounds. The cost per pound of calf birth weight was $0.59.

Crested wheatgrass, alfalfa, and corn silage were balanced in a dry lot ration to meet the requirements of a cow during the early lactation production period. This balanced ration had production costs of $37.50 per acre and forage dry matter costs of $50.00 per ton. This ration would be fed at 30.0 lbs DM/day to provide 2.7 lbs CP/day. Production of the forages in this ration required 0.60 acres per month and cost $0.75 per day, $22.50 per month, or $45.00 for the 60-day production period. Mineral supplementation cost $3.00 per period. Total feed cost was $48.00, or $0.80 per day, during the early lactation period. The cost of calf weight gain was $0.42 per pound.

The native range period of the 6.0-month seasonlong treatment was 183 days. Cow weight gain was 0.12 lbs per day and 0.91 lbs per acre; accumulated weight gain was 21.96 lbs. Calf weight gain was 1.80 lbs per day and 13.59 lbs per acre; accumulated weight gain was 329.40 lbs. Each cow-calf pair was allotted 24.24 acres, at a cost of $8.76 per acre. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $230.58 per calf, and the net returns after pasture costs were $18.24 per cow-calf pair and $0.75 per acre. Grazing for 6.0 months on the 6.0-month seasonlong strategy, a lactating cow and her calf used 4.04 acres per month, at a cost of $35.39 per month. Total feed cost was $212.34, or $1.16 per day, during the lactation period. Each accumulated pound of calf weight cost $0.64 on the native range pasture of the 6.0-month seasonlong strategy.

Lactating cows that grazed native rangeland on the 6.0-month seasonlong strategy for 30 days between mid October and mid November lost 2.65 pounds per day and lost 39.50 pounds per acre; accumulated weight loss was 79.40 pounds per month. Calf weight gain was 0.59 pounds per day and 8.82 pounds per acre; accumulated weight gain was 17.73 pounds. Each cow-calf pair was allotted 4.04 acres per month, at a cost of $1.16 per day, or $35.39 per month. When calf accumulated weight was assumed to have a value of $0.70/lb, the gross return was $12.41 per calf, and the net returns after pasture costs were a loss of $22.98 per cow-calf pair and a loss of $5.69 per acre. Each accumulated pound of calf weight cost $1.99 on the 6.0-month seasonlong management strategy during mid October to mid November.

Total feed costs for the 6.0-month seasonlong management strategy were $329.51 for a 12-month production period. Calf weaning weight was 538.40 pounds. When calf weaning weight was assumed to have a value of $0.70 per pound, the gross return was $376.88 per calf, and the net returns after 12-month pasture-forage costs were $47.37 per cow-calf pair and $1.74 per acre. Each pound of calf weaning weight cost $0.61 for the 12-month production period.

4.5-month seasonlong

Cows on the 4.5-month seasonlong management strategy were fed mature crested wheatgrass hay for 32 days, during the dry gestation production period. Crested wheatgrass cut late, at a mature plant stage, has a crude protein content of around 6.4%. This low-quality perennial grass hay had production costs of $28.11 per acre, forage dry matter costs of $34.80 per ton, and crude protein costs of $0.28 per pound. Late-cut crested wheatgrass hay would be fed at 23.4 lbs DM/day to provide 1.5 lbs CP/day. An additional 0.6 lbs of roughage per day, at a cost of $0.34 per period, would need to be provided. Production of late-cut crested wheatgrass hay to feed a cow during the dry gestation production period required 0.44 acres per month and cost $0.41 per day, $12.32 per month, or $13.12 per period. Total feed cost was $13.46, or $0.42 per day, during the dry gestation period.

Cows were fed mature crested wheatgrass hay during the third trimester production period. Late-cut mature crested wheatgrass hay would need to be fed at 29.7 lbs DM/day to provide 1.9 lbs CP/day. The nutrient content of mature crested wheatgrass hay is below the dietary requirements of a cow in the third trimester. An additional 0.33 lbs of crude protein per day, at a cost of $8.91 per period, would need to be provided when mature crested wheatgrass hay is fed at the dry matter requirement of 24 lbs DM/day. Production of mature crested wheatgrass hay to feed a cow in the third trimester required 0.45 acres per month and cost $0.52 per day, $15.60 per month, or $46.80 for the 90-day production period. Total feed cost was $55.71, or $0.62 per day, during the third trimester period. The calves were born in mid March, at an average weight of 95 pounds. The cost per pound of calf birth weight was $0.59.

Crested wheatgrass, alfalfa, and corn silage were balanced in a dry lot ration to meet the requirements of a cow during the early lactation production period. This balanced ration had production costs of $37.50 per acre and forage dry matter costs of $50.00 per ton. This ration would be fed at 30.0 lbs DM/day to provide 2.7 lbs CP/day. Production of the forages in this ration required 0.60 acres per month and cost $0.75 per day, $22.50 per month, or $33.75 for the 45-day production period. Mineral supplementation cost $2.25 per period. Total feed cost was $36.00, or $0.80 per day, during the early lactation period. The cost of calf weight gain was $0.42 per pound.

The spring crested wheatgrass complementary pasture period was 31 days. Cow weight gain was 1.95 lbs per day and 32.86 lbs per acre; accumulated weight gain was 60.45 lbs. Calf weight gain was 1.91 lbs per day and 32.18 lbs per acre; accumulated weight gain was 59.21 lbs. Each cow-calf pair was allotted 1.88 acres, at a cost of $8.76 per acre. Total feed cost was $16.47, or $0.52 per day, during the spring lactation period. The cost of calf weight gain was $0.27 per pound. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $41.45 per calf, and the net returns after pasture costs were $24.98 per cow-calf pair and $13.29 per acre on crested wheatgrass pasture.

The native range period of the 4.5-month seasonlong treatment was 137 days. Cow weight gain was 0.34 lbs per day and 3.67 lbs per acre; accumulated weight gain was 46.58 lbs. Calf weight gain was 2.09 lbs per day and 22.55 lbs per acre; accumulated weight gain was 286.33 lbs. Each cow-calf pair was allotted 12.70 acres, at a cost of $8.76 per acre. Total feed cost was $111.25, or $0.81 per day, during the summer lactation period. The cost of calf weight gain was $0.39 per pound. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $200.43 per calf, and the net returns after pasture costs were $89.18 per cow-calf pair and $7.02 per acre on native range.

Livestock grazed a cropland aftermath pasture during the fall lactation period. Lactating cows that grazed cropland aftermath of annual cereal residue between mid October and mid November lost 1.26 pounds per day and lost 7.27 pounds per acre. Calf weight gain was 0.42 pounds per day and 1.90 pounds per acre; accumulated weight gain was 12.57 pounds. Each cow-calf pair was allotted 6.63 acres of crop aftermath per month, at the assessed value of $2.00 per acre. Total feed cost was $13.26, or $0.44 per day, during the fall lactation period. When calf accumulated weight was assumed to have a value of $0.70/lb, the gross return was $8.80 per calf, and the net returns after pasture costs were a loss of $4.46 per cow-calf pair and a loss of $0.67 per acre. Each accumulated pound of calf weight cost $1.05 on cropland aftermath during mid October to mid November.

The combined crested wheatgrass, native range, and cropland aftermath pasture types for the 4.5-month seasonlong strategy yielded an accumulated cow weight gain of 69.23 lbs and an accumulated calf weight gain of 358.11 lbs on 21.21 acres in 198 days, at a cost of $140.98 per cow-calf pair. When calf accumulated weight was assumed to have a value of $0.70 per pound, the net returns after pasture costs were $109.70 per cow-calf pair and $5.17 per acre for portions of the year that cow-calf pairs were grazing pastures. Grazing for 6.5 months on the 4.5-month seasonlong strategy, a lactating cow and her calf used 3.26 acres per month, at a cost of $0.71 per day, or $21.72 per month. Each accumulated pound of calf weight cost $0.39 on the pastures of the 4.5-month seasonlong strategy.

Total feed costs for the 4.5-month seasonlong management strategy were $246.15 for a 12-month production period. Calf weaning weight was 538.61 pounds. When calf weaning weight was assumed to have a value of $0.70 per pound, the gross return was $377.03 per calf, and the net returns after 12-month pasture-forage costs were $130.88 per cow-calf pair and $5.47 per acre. Each pound of calf weaning weight cost $0.46 for the 12-month production period.

4.0-month deferred

Cows on the 4.0-month deferred management strategy grazed cropland aftermath for 32 days, during the dry gestation production period. Crop aftermath of annual cereal stubble has very low crude protein content. A dry gestating cow grazed 7.10 acres of crop aftermath per period, at a cost of $13.26 per month when crop aftermath production cost was valued at $2.00 per acre. Total feed cost was $14.20, or $0.44 per day, during the dry gestation period. This forage source was below the crude protein requirements of a dry gestating cow. Dry cows grazing crop aftermath lost an average of 1.14 lbs per day and lost an average of 4.82 lbs per acre; accumulated weight loss was 36.48 lbs per period.

Cows were fed mature crested wheatgrass hay during the third trimester production period. Crested wheatgrass cut late, at a mature plant stage, has a crude protein content of around 6.4%. This low-quality hay had production costs of $28.11 per acre, forage dry matter costs of $34.80 per ton, and crude protein costs of $0.28 per pound. This late-cut hay would need to be fed at 29.7 lbs DM/day to provide 1.9 lbs CP/day. The nutrient content of mature crested wheatgrass hay is below the dietary requirements of a cow in the third trimester. An additional 0.33 lbs of crude protein per day, at a cost of $8.91 per period, would need to be provided when mature crested wheatgrass hay is fed at the dry matter requirement of 24 lbs DM/day. Production of mature crested wheatgrass hay to feed a cow in the third trimester required 0.45 acres per month and cost $0.52 per day, $15.60 per month, or $46.80 for the 90-day production period. Total feed cost was $55.71, or $0.62 per day, during the third trimester period. The calves were born in mid March, at an average weight of 95 pounds. The cost per pound of calf birth weight was $0.59.

Crested wheatgrass, alfalfa, and corn silage were balanced in a dry lot ration to meet the requirements of a cow during the early lactation production period. This balanced ration had production costs of $37.50 per acre and forage dry matter costs of $50.00 per ton. This ration would be fed at 30.0 lbs DM/day to provide 2.7 lbs CP/day. Production of the forages in this ration required 0.60 acres per month and cost $0.75 per day, $22.50 per month, or $33.75 for the 45-day production period. Mineral supplementation cost $2.25 per period. Total feed cost was $36.00, or $0.80 per day, during the early lactation period. The cost of calf weight gain was $0.42 per pound.

The spring crested wheatgrass complementary pasture period was 76 days. Cow weight gain was 0.91 lbs per day and 16.63 lbs per acre; accumulated weight gain was 69.16 lbs. Calf weight gain was 1.79 lbs per day and 32.70 lbs per acre; accumulated weight was 136.04 lbs. Each cow-calf pair was allotted 4.16 acres, at a cost of $8.76 per acre. Total feed cost was $36.44, or $0.48 per day, during the spring lactation period. The cost of calf weight gain was $0.27 per pound. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $95.23 per calf, and the net returns after pasture costs were $58.78 per cow-calf pair and $14.13 per acre on crested wheatgrass pasture.

The native range period of the 4.0-month deferred treatment was 122 days. Cow weight gain was 0.32 lbs per day and 4.40 lbs per acre; accumulated weight gain was 39.04 lbs. Calf weight gain was 1.80 lbs per day and 24.73 lbs per acre; accumulated weight gain was 219.60 lbs. Each cow-calf pair was allotted 8.88 acres, at a cost of $8.76 per acre. Total feed cost was $77.79, or $0.64 per day, during the late-season lactation period. The cost of calf weight gain was $0.35 per pound. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $153.72 per calf, and the net returns after pasture costs were $75.93 per cow-calf pair and $8.55 per acre on native range.

Lactating cows that grazed on the 4.0-month deferred strategy for 30 days between mid October and mid November lost 0.74 pounds per day and lost 9.96 pounds per acre. Calf weight gain was 0.77 pounds per day and 10.36 pounds per acre; accumulated weight gain was 23.10 pounds. Each cow-calf pair was allotted 2.22 acres per month, at a cost of $0.65 per day, or $19.53 per month. When calf accumulated weight was assumed to have a value of $0.70/lb, the gross return was $16.77 per calf, and the net returns after pasture costs were a loss of $3.36 per cow-calf pair and a loss of $1.51 per acre. Each accumulated pound of calf weight cost $0.85 on the 4.0-month deferred management strategy during mid October to mid November.

The combined pasture types for the 4.0-month deferred strategy yielded an accumulated cow weight gain of 108.20 lbs and an accumulated calf weight gain of 355.64 lbs on 13.04 acres in 198 days, at a cost of $114.23 per cow-calf pair. When calf accumulated weight was assumed to have a value of $0.70 per pound, the net returns after pasture costs were $134.72 per cow-calf pair and $10.33 per acre for all portions of the grazing season. Grazing for 6.5 months on the 4.0-month deferred strategy, a lactating cow and her calf used 2.01 acres per month, at a cost of $0.58 per day, or $17.31 per month. Each accumulated pound of calf weight cost $0.32 on the pastures of the 4.0-month deferred strategy.

Total feed costs for the 4.0-month deferred management strategy were $220.14 for a 12-month production period. Calf weaning weight was 536.14 pounds. When calf weaning weight was assumed to have a value of $0.70 per pound, the gross return was $375.30 per calf, and the net returns after 12-month pasture-forage costs were $155.16 per cow-calf pair and $6.93 per acre. Each pound of calf weaning weight cost $0.41 for the 12-month production period.

4.5-month twice-over rotation

Cows on the 4.5-month twice-over rotation management strategy were fed early cut forage barley hay for 32 days, during the dry gestation production period. Forage barley hay cut early, at the milk stage, has a crude protein content of 13.0%. This forage barley hay had production costs of $68.21 per acre, forage dry matter costs of $28.80 per ton, and crude protein costs of $0.11 per pound. Early cut forage barley hay would be fed at 11.5 lbs DM/day to provide 1.5 lbs CP/day. An additional 12.5 lbs of roughage per day, at a cost of $7.00 per period, would need to be provided. Production of early cut forage barley hay to feed a cow during the dry gestation production period required 0.07 acres per month and cost $0.16 per day, $4.80 per month, or $5.12 per period. Total feed cost was $12.12, or $0.38 per day, during the dry gestation period.

Cows were fed early cut forage barley hay during the third trimester production period. Forage barley hay cut at the milk stage would be fed at 14.4 lbs DM/day to provide 1.9 lbs CP/day. An additional 9.6 lbs of roughage per day, at a cost of $14.96 per period, would need to be provided. Production of early cut forage barley hay to feed a cow in the third trimester required 0.09 acres per month and cost $0.21 per day, $6.30 per month, or $18.90 for the 90-day production period. Total feed cost was $33.86, or $0.38 per day, during the third trimester period. The calves were born in mid March, at an average weight of 95 pounds. The cost per pound of calf birth weight was $0.36.

Cows were fed a dry lot ration of early cut forage barley hay during the early lactation production period. Forage barley hay cut at the milk stage would be fed at 21.0 lbs DM/day to provide 2.7 lbs CP/day. An additional 6.0 lbs of roughage per day, at a cost of $4.73 per period, would need to be provided. Production of early cut forage barley hay to feed a cow during early lactation required 0.13 acres per month and cost $0.30 per day, $9.00 per month, or $13.50 per period. Total feed cost was $18.23, or $0.41 per day, during the early lactation period. The cost of calf weight gain was $0.21 per pound.

The spring crested wheatgrass complementary pasture period was 31 days. Cow weight gain was 2.68 lbs per day and 110.77 lbs per acre; accumulated weight gain was 83.08 lbs on 0.75 acres. Calf weight gain was 2.18 lbs per day and 90.11 lbs per acre; accumulated weight gain was 67.58 lbs on 0.75 acres. Each cow-calf pair was allotted 0.75 acres, at a cost of $21.26 per acre. Total feed cost was

$15.95, or $0.51 per day, during the spring lactation period. The cost of calf weight gain was $0.24 per pound. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $47.31 per calf, and the net returns after pasture costs were $31.36 per cow-calf pair and $41.82 per acre on fertilized crested wheatgrass pasture.

The native range period of the 4.5-month twice-over rotation treatment was 137 days. Cow weight gain was 0.62 lbs per day and 9.44 lbs per acre; accumulated weight gain was 84.94 lbs. Calf weight gain was 2.21 lbs per day and 33.64 lbs per acre; accumulated weight gain was 302.77 lbs. Each cow-calf pair was allotted 9.00 acres, at a cost of $8.76 per acre. Total feed cost was $78.84, or $0.58 per day, during the summer lactation period. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $211.94 per calf, and the net returns after pasture costs were $133.10 per cow-calf pair and $14.79 per acre on native range.

Livestock grazed an Altai wildrye complementary pasture during the fall lactation period. Lactating cows that grazed Altai wildrye pastures for 30 days between mid October and mid November gained 0.55 lbs per day and 11.87 lbs per acre; accumulated weight gain was 16.50 lbs. Calf weight gain was 1.73 lbs per day and 37.96 lbs per acre; accumulated weight gain was 52.77 lbs. Each cow-calf pair was allotted 1.39 acres, at a cost of $8.76 per acre. Total feed cost was $12.00, or $0.40 per day, during the fall lactation period. The cost of calf weight gain was $0.23 per pound.

The combined pasture types for the 4.5-month twice-over rotation strategy yielded an accumulated cow weight gain of 184.52 lbs and an accumulated calf weight gain of 423.12 lbs on 11.14 acres in 198 days, at a cost of $106.97 per cow-calf pair. When calf accumulated weight was assumed to have a value of $0.70 per pound, the net returns after pasture costs were $189.21 per cow-calf pair and $16.98 per acre for all pastures of the grazing season. Grazing for 6.5 months on the 4.5-month twice-over rotation strategy, a lactating cow and her calf used 1.72 acres per month, at a cost of $0.54 per day, or $16.21 per month. Each accumulated pound of calf weight cost $0.25 on the pastures of the 4.5-month twice-over rotation strategy.

Total feed costs for the 4.5-month twice-over rotation management strategy were $171.00 for a 12-month production period. Calf weaning weight was 603.62 pounds. When calf weaning weight was assumed to have a value of $0.70 per pound, the gross return was $422.53 per calf, and the net returns after 12-month pasture-forage costs were $251.53 per cow-calf pair and $21.54 per acre. Each pound of calf weaning weight cost $0.28 for the 12-month production period.

This study evaluated and compared the pasture and harvested-forage costs for the dry gestation, third trimester, early lactation, spring lactation, summer lactation, and fall lactation production periods and the total 12-month pasture-forage costs for five 12-month management strategies. One management strategy was developed from native range herbage biomass data as a 12-month grazing system on native range pastures, with none of the feed provided as harvested forage. Three of the management strategies followed traditional practices, with typical variations of mature crested wheatgrass hay, crested wheatgrass pasture, native range pasture, and cropland aftermath pasture. One management strategy was the twice-over rotation system with complementary spring and fall pastures; developed specifically for the Northern Plains, this management strategy was designed to meet the biological requirements of the plants, facilitate the functioning of ecological processes, and counterbalance problematic biological conditions inherent in the grassland ecosystems so that cow and calf weight performance, grass plant performance, and wildlife habitat are improved over those produced on traditional management practices.

The management strategy with 12 months of grazing on native range pastures and no harvested-forage feed had the highest costs during all production periods, in all cost categories except production costs per acre. These high costs resulted in negative net returns after pasture costs when calves were sold at $0.70 per pound.

The three management strategies with traditional practices had similar calf performance and calf weaning weights. All three traditional management strategies had positive net returns after pasture and forage costs, per cow-calf pair ($47.37 to $155.16) and per acre ($1.74 to $6.93), when calves were sold at $0.70 per pound. These three management strategies, however, did not have very high profit margins.

The twice-over rotation management strategy with three-pasture native range rotation system, spring and fall domesticated grass complementary pastures, and early cut annual cereal hay as the harvested-forage feed had the lowest land area per month; the lowest land area per 12-month period; the lowest forage feed cost during dry gestation, third trimester, early lactation, spring lactation, summer lactation, and fall lactation production periods; the lowest total 12-month feed cost; and the lowest crude protein supplementation costs. The twice-over rotation management strategy also had the lowest cost per pound of calf birth weight ($0.36), the lowest cost per pound of calf accumulated weight ($0.25), and the lowest cost per pound of calf weaning weight ($0.28). The twice-over rotation management strategy had the highest net returns after pasture and forage costs, per cow-calf pair ($251.53) and per acre ($21.54), when calves were sold at $0.70 per pound.

The individual cow data presented for 12-month management strategies were projected to a herd of 300 cows (table 10) and to a production land base of 5,000 acres (table 11). The net returns after pasture and forage costs from the management strategies with 300 cows ranged from -$29,424 to $75,459 per year. The net returns after pasture and forage costs from the management strategies with 5,000 production acres ranged from -$9,808 to $107,655 per year. The cow genetics and the land production capabilities were assumed to be the same across all treatments. The differences in the net returns result from the differences in the biological effectiveness and the nutrient capture and conversion efficiency of the various management strategies.

The levels of biological effectiveness and of nutrient capture and conversion efficiency among the 12-month management strategies are highly variable. A management strategy that improves biological effectiveness meets the biological requirements of the plants, facilitates the functioning of ecological processes at potential levels, and counterbalances problematic biological conditions inherent in the grassland ecosystem. Biologically effective management practices produce the most biological advantages and the fewest biological disadvantages.

A management strategy that improves the efficiency of nutrient capture and conversion increases the quantity of herbage and nutrients produced on a land base and effectively captures a high proportion of the produced nutrients by combining pasture and forage types so that the herbage production curves and nutritional quality curves are coordinated with the 12-month dietary quantity and quality requirement curves of cow production periods. Efficient conversion of nutrients into a saleable product can be performed by modern high-performance livestock when nutrients are available for consumption at the times and in the amounts that the livestock require during each production period.

The availability of crude protein to livestock at the required times and in the required amounts was different on the various management strategies. The crude protein content of pasture-forage feed provided to cows was below livestock requirements for 273 days on the 12-month repeated seasonal, 196 days on the 6.0-month seasonlong and 4.5-month seasonlong, 259 days on the 4.0-month deferred, and 15 days, some years, on the 4.5-month twice-over rotation management strategies. Supplemental crude protein was made available to the cows for 197 days on the 12-month repeated seasonal and for 90 days on the 6.0-month seasonlong, 4.5-month seasonlong, and 4.0-month deferred management strategies. Crude protein was deficient in the livestock feed for 76 days on the 12-month repeated seasonal, 106 days on the 6.0-month seasonlong and 4.5-month seasonlong, and 169 days on the 4.0-month deferred management strategies.

The weight production performance levels of the cows and calves on these four traditional management strategies were below the genetic capabilities of the animals because amounts of nutrients were deficient in the feed during long portions of the 12-month production cycle. Modern high-performance cattle have reduced levels of production efficiency when their diet is deficient in nutrients. Long periods with nutrient deficiency caused from feeds provided result in calves with weaning weights below potential and in high annual expenses for cow maintenance.

Crude protein supplementation was not required on the twice-over rotation management strategy because grazing periods on crested wheatgrass, native rangeland, and Altai wildrye pastures were coordinated so that the nutritional quality of the various forage types and the nutritional requirements of the livestock matched over the entire grazing season; this coordination of nutrient supply and demand improved the individual animal performance.

Unfertilized crested wheatgrass pastures have adequate crude protein levels for lactating cows during May and most of June. Fertilized crested wheatgrass pastures have adequate crude protein during May and the early portion of June.

The native range forage on the twice-over rotation management strategy was not deficient in crude protein during the period from early August until the end of the grazing season, unlike the forage on the traditional management strategies. The grazing periods on the twice-over rotation system are coordinated with grass growth stages, and a small amount of leaf material is removed between the third-leaf stage and the flowering stage. This timed defoliation activates secondary tiller development from axillary buds, activates plant physiological mechanisms, and stimulates rhizosphere organism activity that increases nutrient flow and plant growth (Manske 1999 c): the result is increased plant basal cover, increased aboveground herbage biomass, and improved nutritional quality of herbage. The increases in herbage quantity and quality permit increased stocking rates, reduced acreage required to carry a cow-calf pair for the season, and increased total accumulated weight gain.

Manipulation of secondary tiller growth of grasses on the native range pastures of the twice-over system improves livestock performance for two to two and a half months, until late September or mid October, but the biology of native grass plants does not permit extending this improved performance longer. Nutritional quality of native range herbage is below the requirements of lactating cows after mid October, and grazing animals must be moved to an alternative forage source if their nutritional requirements are to be met.

Perennial grass forages that meet the nutritional requirements of lactating cows after mid October include Altai and Russian wildryes. The wildryes are excellent fall pastures because they retain nutrient quality in the aboveground portions of the plant until about mid November, much later than do other types of perennial grasses, in which translocation of aboveground cell components and the resulting decreases in crude protein levels occur relatively early during the grazing season.

Annual cereal hay was fed to the cows on the twice-over rotation management strategy for 167 days, or 5.5 months. This harvested forage had the highest production costs per acre of all the forage types but had the lowest feed costs per day and per production period. Harvested forages are usually viewed as expensive feeds because the production costs per acre are higher than pasture rent per acre and a high percentage of the costs are labor and equipment expenses.

The annual cereal hay used as harvested feed on the twice-over rotation management strategy was forage barley cut at the milk stage. It was cut at an early plant growth stage so that the maximum quantity of crude protein would be captured per acre. This harvest time resulted in the lowest cost per unit of nutrient possible and the lowest feed cost possible for that forage type. The growth pattern of forage plants does not produce the greatest amount of crude protein and the greatest amount of dry matter at the same time. Planning the harvest time to capture the greatest amount of dry matter results in harvest of forage with the lowest cost per unit of dry matter but would not result in harvest of the forage with the lowest feed costs. Forage barley hay cut at the milk stage captured around 600 pounds of crude protein per acre, at a cost of $0.11 per pound of crude protein. At a forage feed cost that ranged between $0.16 and $0.30 per day, forage barley hay was the lowest-cost feed. Early cut forage barley has greater crude protein content than the amount required by cows. High-quality forage barley hay would not be fed alone, but would be supplemented with some amount of low-cost roughage. The feed costs for forages that are harvested to yield the greatest amount of crude protein and supplemented with roughage are lower than the feed costs for forages that are harvested to yield the greatest amount of dry matter and supplemented with crude protein.

The 4.5-month twice-over rotation management strategy is the most biologically effective and nutrient-efficient management strategy. Cows on this management strategy produced 603.62 pounds of calf on 11.68 acres, at a total 12-month feed cost of $171.00, or at a cost of $0.28 per pound of calf weaning weight, with a net return after pasture and forage costs of $251.53 per cow-calf pair and $21.54 per acre.

Discussion

The pasture and harvested-forage costs evaluated during this study were pasture or land rent values per acre; production costs per acre; costs per unit of dry matter; costs per unit of nutrient (crude protein); land area per animal unit; forage feed costs per day, per month, or per production period; and costs per pound of calf weight gain.

Pasture and land rent values ranged from $2.00 to $22.07 per acre. Production costs ranged from $2.00 to $68.21 per acre. Cost of forage dry matter ranged from $27.04 to $140.16 per ton. These three costs are important, but none of them should be the sole criterion on which management decisions are based. Production costs per acre and pasture or land rent per acre do not accurately reflect livestock production costs because forage dry matter weight per acre and nutrient weight per acre captured through grazing or haying vary with forage type and plant growth stage and the variations are not proportional to production costs or land rent values per acre. Forage dry matter costs per unit of weight do not accurately reflect livestock production costs because of the variable quantity of nutrients contained within the dry matter and the resulting differences in the amount of dry matter needed to provide adequate quantities of nutrients for livestock.

Cost per unit of nutrient is an important indicator of livestock production costs. Nutrient cost per unit of weight is related to the forage dry matter costs and the quantity of nutrients per unit of forage weight. The costs per unit of nutrient (crude protein) ranged from $0.11 to $1.26 per pound. A 1200-pound cow with a calf born in March requires 837 pounds of crude protein for a 12-month period. The cost per pound of crude protein directly affects the total production costs for that cow.

The size and the cost of the land area required to provide adequate forage dry matter and nutrients for a cow contribute substantially to total production costs. The size of the land area ranged from 11.68 acres to 49.58 acres per animal unit for a 12-month period. The costs of the land area ranged from $118.88 to $434.33 per animal unit for a 12-month period. The land area cost, which includes the costs of dry matter and nutrients, constitutes from 69.5% to 92.3% of the total pasture-forage production costs for a cow. These costs are affected by the efficiency of nutrient capture. The greater the quantity of the produced nutrients captured from a land base, the smaller the land area required by an animal unit and the lower the production costs. The quantities of dry matter and nutrients produced per unit of land are affected by the health status of a grassland ecosystem. The implementation of a management strategy that improves the health performance levels of a grassland ecosystem and the efficiency of nutrient capture and conversion will increase the quantity of herbage and nutrients produced and the quantity of nutrients captured and converted, and will, therefore, help to reduce livestock production costs.

Forage feed cost is an important indicator of livestock production costs. Forage feed costs include production costs per acre, cost or weight of harvested or consumed dry matter, and cost or weight of harvested or consumed crude protein. Forage feed costs ranged from $144.31 to $433.78 per animal unit for a 12-month period and from $0.40 to $1.19 per day. Forage feed costs are the combined costs for livestock feed that is produced from the 12-month land base assigned to each animal-production unit. During periods in which the quantity or quality of this produced feed falls below the quantity or quality of the feed required by livestock, additional nutrients or dry matter from other sources need to be supplemented. The costs of supplemented nutrients or dry matter plus the forage feed costs are the total feed costs for an animal unit for a 12-month period. The total feed costs ranged from $171.00 to $470.76 per animal unit for a 12-month period and from $0.47 to $1.29 per day.

Cost per pound of calf weight is an important diagnostic value for the evaluation of livestock production costs and pasture-forage management strategies. The cost per pound of calf weight is the culmination of a management strategy's positive and negative effects on grass plant and livestock performance. Cost per pound of calf weight is the combined rent costs, production costs, dry matter costs, nutrient costs, land area costs, forage feed costs, supplementation costs, and the effects the management strategy's biological effectiveness and nutrient capture and conversion efficiency have on all pasture and forage costs. The management strategy that is the most biologically effective and that captures and converts nutrients most efficiently will have the lowest cost per pound of calf weight; the twice-over rotation management strategy has the lowest cost per pound of calf birth weight, accumulated weight, and weaning weight.

Conclusion

The profit margin of the beef production industry in the Northern Plains is low because the economic value for pounds of calf weight at market is close to the cost of producing the pounds of calf weight. Pasture and harvested-forage costs are the major portion of livestock production costs. The pasture-forage costs of traditional management practices and alternative management practices must be understood and the factors that contribute to high beef-production costs need to be identified in order for livestock production costs to be effectively reduced.

Evaluation of the pasture and forage costs of 12-month management strategies has shown that these costs are largely determined by the biological effectiveness and nutrient capture and conversion efficiency of the management strategy. Reduction of pasture and forage costs requires improvement of the biological effectiveness and the nutrient capture and conversion efficiency of management strategies. These biological and nutritional aspects of 12-month pasture-forage management strategies can be increased through the improvement of four factors.

- increasing herbage and nutrient production by placing the biological requirements of plants and the ecosystem processes as the highest management priority and by coordinating grazing and harvest periods with plant growth stages.
- increasing nutrient capture efficiency by timing grazing and harvest periods to remove greater amounts of nutrients rather than greater amounts of dry matter. Supplementation of dry matter is lower cost than supplementation of crude protein.
- increasing nutrient conversion efficiency by providing adequate nutrients throughout the cows' 12-month production cycle because high-performance livestock perform at greater efficiencies when not limited by periods with nutrient deficiency.
- increasing pasture-forage system efficiency by combining pasture and forage types in a 12-month sequence so that the herbage production curves and nutritional quality curves are coordinated with the 12-month dietary quantity and quality requirement curves of cow production periods.

The 12-month pasture-forage management strategy that has great biological effectiveness, efficient nutrient capture, efficient nutrient conversion, and an efficient pasture-forage-livestock system will have lower production costs per pound of calf weight and higher profit margins.

Beef production is the last meat industry to improve the efficiency of feed management systems. The traditional pasture-forage management strategies used in the Northern Plains were developed during the era of low-performance livestock. During the past several decades the type of livestock in the region has shifted to a fast-growing, high-performance animal, but pasture-forage management strategies have not been adjusted to provide nutrients at the times and in the amounts required by high-performance animals and to take full advantage of the livestock's genetic potential. Traditional management practices do not efficiently provide adequate feed for high-performance livestock to produce high profit margins. Beef production profit margins will remain small or decrease unless improved efficient 12-month pasture-forage management strategies are implemented.

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Tables and Graphs

Table 1. Twelve-month pasture and forage costs for the 12-month repeated seasonal management strategy.

		Dry Gestation	Third Trimester	Early Lactation	Lactation	Lactation	Late Lactation	
Season		**Late Fall**	**Winter**	**Early Spring**	**Spring**	**Summer**	**Early Late Fall**	
Days		32	90	45	31	137	15	15
Herbage Wt	lb/ac	725	580	480	780	1450	870	725
Forage Wt	lb/ac	180	145	125	195	363	218	180
Forage DM/AU	lb/d	24	24	27	30	30	30	30
Production Cost	$/ac	8.76	8.76	8.76	8.76	8.76	8.76	8.76
Forage DM Cost	$/ton	97.33	120.83	140.16	89.85	48.26	80.37	97.33
Land Area/Mo	ac	4.00	4.97	6.48	4.62	2.52	4.20	5.00
Land Area/PP	ac	4.27	14.90	9.72	4.77	11.32	2.10	2.50
Land Cost/Mo	$/mo	35.04	43.54	56.76	40.47	22.08	36.79	43.80
Land Cost/PP	$/pp	37.41	130.52	85.15	41.79	99.16	18.40	21.90
Feed Cost/D	$/d	1.17	1.45	1.89	1.35	0.72	1.21	1.46
Feed Cost/Mo	$/mo	35.10	43.50	56.70	40.50	21.60	36.30	43.80
Feed Cost/PP	$/pp	37.44	130.50	85.05	41.85	98.64	18.40	21.90
Crude Protein	%	4.8	4.8	9.2	16.3	9.6	4.8	4.8
Crude Protein	lb/ac	8.64	6.96	11.50	31.79	34.85	10.46	8.64
Cost CP	$/lb	1.01	1.26	0.76	0.28	0.25	0.34	1.01
Cow CP/D	lb/d	1.49	1.87	2.73	2.51	2.51	2.51	2.51
Supplementation								
Roughage	lb/d							
CP/d	lb/d	0.34	0.72	0.25	0.0	0.0	1.21	1.21

Sup. Cost/PP	$/pp	3.26	19.44	3.38	0.0	0.0	5.45	5.45
Total Feed Cost	$/pp	40.70	149.94	88.43	41.85	98.64	23.85	27.35
Cost/D	$/d	1.27	1.67	1.97	1.35	0.72	1.59	1.82

Table 2. Twelve-month pasture and forage costs for the 6.0-month seasonlong management strategy.

		Dry Gestation	Third Trimester	Early Lactation	Lactation	Lactation	Late Lactation
Season		**Late Fall**	**Winter**	**Early Spring**	**Spring**	**Summer**	**Early LateFall**
Days		32	90	60	16	137	30
Herbage Wt	lb/ac				906	906	891
Forage Wt	lb/ac	1600	1600	1500	226	226	223
Forage DM/AU	lb/d	24	24	30	30	30	30
Production Cost	$/ac	28.11	28.11	37.50	8.76	8.76	8.76
Forage DM Cost	$/ton	34.80	34.80	50.00	77.52	77.50	78.57
Land Area/Mo	ac	0.44	0.45	0.60	4.04	4.04	4.04
Land Area/PP	ac	0.47	1.35	1.20	2.10	18.10	4.04
Land Cost/Mo	$/mo	6.26	6.40		35.39	35.39	35.39
Land Cost/PP	$/pp	6.68	19.20		18.40	158.55	35.39
Feed Cost/D	$/d	0.41	0.52	0.75	1.16	1.16	1.16
Feed Cost/Mo	$/mo	12.32	15.60	22.50	35.39	35.39	35.39
Feed Cost/PP	$/pp	13.12	46.80	45.00	18.40	158.55	35.39
Crude Protein	%	6.4	6.4				
Crude Protein	lb/ac	102	102				
Cost CP	$/lb	0.28	0.28				
Cow CP/D	lb/d	1.49	1.87	2.73	2.51	2.51	2.51

Supplementation							
Roughage	lb/d	0.6					
CP/d	lb/d		0.33				
Sup. Cost/PP	$/pp	0.34	8.91	3.00			
Total Feed Cost	$/pp	13.46	55.71	48.00	18.40	158.55	35.39
Cost/D	$/d	0.42	0.62	0.80	1.15	1.16	1.18

Table 3. Twelve-month pasture and forage costs for the 4.5-month seasonlong management strategy.

		Dry Gestation	**Third Trimester**	**Early Lactation**	**Lactation**	**Lactation**	**Late Lactation**
Season		**Late Fall**	**Winter**	**Early Spring**	**Spring**	**Summer**	**Early LateFall**
Days		32	90	45	31	137	30
Herbage Wt	lb/ac				1980	1280	270
Forage Wt	lb/ac	1600	1600	1500	495	320	135
Forage DM/AU	lb/d	24	24	30	30	30	30
Production Cost	$/ac	28.11	28.11	37.50	8.76	8.76	2.00
Forage DM Cost	$/ton	34.80	34.80	50.00	35.39	54.75	29.63
Land Area/Mo	ac	0.44	0.45	0.60	1.82	2.86	6.63
Land Area/PP	ac	0.47	1.35	0.90	1.88	12.70	6.63
Land Cost/Mo	$/mo	6.26	6.40		15.94	25.05	13.26
Land Cost/PP	$/pp	6.68	19.20		16.47	111.25	13.26
Feed Cost/D	$/d	0.41	0.52	0.75	0.52	0.81	0.44
Feed Cost/Mo	$/mo	12.32	15.60	22.50	15.60	24.30	13.26
Feed Cost/PP	$/pp	13.12	46.80	33.75	16.47	111.25	13.26
Crude Protein	%	6.4	6.4				
Crude Protein	lb/ac	102	102				

Cost CP	$/lb	0.28	0.28				
Cow CP/D	lb/d	1.49	1.87	2.73	2.51	2.51	2.51
Supplementation							
Roughage	lb/d	0.6					
CP/d	lb/d		0.33				
Sup. Cost/PP	$/pp	0.34	8.91	2.25			
Total Feed Cost	$/pp	13.46	55.71	36.00	16.47	111.25	13.26
Cost/D	$/d	0.42	0.62	0.80	0.52	0.81	0.44

Table 4. Twelve-month pasture and forage costs for the 4.0-month deferred management strategy.

		Dry Gestation	**Third Trimester**	**Early Lactation**	**Lactation**	**Lactation**	**Late Lactation**
Season		**Late Fall**	**Winter**	**Early Spring**	**Spring**	**Summer**	**Early LateFall**
Days		32	90	45	76		122
Herbage Wt	lb/ac				2192		1649
Forage Wt	lb/ac		1600	1500	548		412
Forage DM/AU	lb/d	24	24	30	30		30
Production Cost	$/ac	2.00	28.11	37.50	8.76		8.76
Forage DM Cost	$/ton	29.63	34.80	50.00	31.97		42.52
Land Area/Mo	ac	6.63	0.45	0.60	1.67		2.22
Land Area/PP	ac	7.10	1.35	0.90	4.16		8.88
Land Cost/Mo	$/mo	13.26	6.40		14.63		19.45
Land Cost/PP	$/pp	14.20	19.20		36.44		77.79
Feed Cost/D	$/d	0.44	0.52	0.75	0.48		0.64
Feed Cost/Mo	$/mo	13.26	15.60	22.50	14.40		19.20

Feed Cost/PP	$/pp	14.20	46.80	33.75	36.44		77.79
Crude Protein	%		6.4				
Crude Protein	lb/ac		102				
Cost CP	$/lb		0.28				
Cow CP/D	lb/d	1.49	1.87	2.73	2.51	2.51	2.51
Supplementation							
Roughage	lb/d						
CP/d	lb/d		0.33				
Sup. Cost/PP	$/pp		8.91	2.25			
Total Feed Cost	$/pp	14.20	55.71	36.00	36.44		77.79
Cost/D	$/d	0.44	0.62	0.80	0.48		0.64

Table 5. Twelve-month pasture and forage costs for the 4.5 twice-over rotation management strategy.

		Dry Gestation	**Third Trimester**	**Early Lactation**	**Lactation**	**Lactation**	**Late Lactation**
Season		**Late Fall**	**Winter**	**Early Spring**	**Spring**	**Summer**	**Early LateFall**
Days		32	90	45	31	137	30
Herbage Wt	lb/ac				4960	1794	2590
Forage Wt	lb/ac	4733	4733	4733	1240	449	648
Forage DM/AU	lb/d	24	24	27	30	30	30
Production Cost	$/ac	68.21	68.21	68.21	21.26	8.76	8.76
Forage DM Cost	$/ton	28.80	28.80	28.80	34.29	39.02	27.04
Land Area/Mo	ac	0.07	0.09	0.13	0.73	2.04	1.39
Land Area/PP	ac	0.07	0.27	0.20	0.75	9.00	1.39
Land Cost/Mo	$/mo	1.54	1.99	2.87	15.52	17.87	12.18
Land Cost/PP	$/pp	1.54	5.96	4.41	15.95	78.84	12.18

Feed Cost/D	$/d	0.16	0.21	0.30	0.51	0.58	0.40
Feed Cost/Mo	$/mo	4.80	6.30	9.00	15.30	17.40	12.00
Feed Cost/PP	$/pp	5.12	18.90	13.50	15.95	78.84	12.00
Crude Protein	%	13.0	13.0	13.0			
Crude Protein	lb/ac	606	606	606			
Cost CP	$/lb	0.11	0.11	0.11			
Cow CP/D	lb/d	1.49	1.87	2.73	2.51	2.51	2.51
Supplementation							
Roughage	lb/d	12.5	9.6	6.0	-	-	-
CP/d	lb/d						
Sup. Cost/PP	$/pp	7.00	14.96	4.73			
Total Feed Cost	$/pp	12.12	33.86	18.23	15.95	78.84	12.00
Cost/D	$/d	0.38	0.38	0.41	0.51	0.58	0.40

Table 6. Pasture-forage returns for production season between calf birth and weaning by 12-month management strategy.

		12.0 M Repeated Seasonal	6.0 M Seasonlong	4.5 M Seasonlong	4.0 M Deferred	4.5 M Twice-over Rotation
Length of Season	days	243	243	243	243	243
Acres/Season	ac	30.41	25.44	22.11	13.94	11.34
Acres/Month	ac	3.80	3.18	2.76	1.74	0.95
Feed Cost/Season	$	280.12	260.34	176.98	150.23	125.02
Calf Gain/Season	lb	437.40*	443.40	443.61	441.14	508.62
Wt. Value @ $0.70/lb	$	306.18	310.38	310.53	308.80	356.03
Calf ADG	lb/d	1.80	1.82	1.83	1.81	2.09
Calf Gain/Acre	lb/ac	14.38	17.43	20.06	31.65	44.85
Net Return/c-c pr	$	26.06	50.04	133.55	158.57	231.01
Net Return/acre	$	0.86	1.97	6.04	11.38	20.37

Cost/lb Accumulated Wt	$	0.64	0.59	0.40	0.34	0.25

*Calf weight estimation based on 1.80 lbs average daily gain.

Table 7. Pasture-forage returns for 12-month production period by 12-month management strategy.

		12.0 M Repeated Seasonal	6.0 M Seasonlong	4.5 M Seasonlong	4.0 M Deferred	4.5 M Twice-over Rotation
Length of 12-months	days	365	365	365	365	365
Acres/12-months	ac	49.58	27.26	23.93	22.39	11.68
Acres/Month	ac	4.13	2.27	1.99	1.87	0.97
Feed Cost/12-months	$	470.76	329.51	246.15	220.14	171.00
Calf Weaning Wt	lb	532.40*	538.40	538.61	536.14	603.62
Wt. Value @ $0.70/lb	$	372.68	376.88	377.03	375.30	422.53
Wt/Day of Age	lb/d	2.19	2.22	2.22	2.21	2.48
Calf Gain/12-month acres	lb/ac	10.74	19.75	22.51	23.95	51.68
Net Return/cow	$	-98.08	47.37	130.88	155.16	251.53
Net Return/12-month acres	$	-1.98	1.74	5.47	6.93	21.54
Cost/lb Weaning Wt	$	0.88	0.61	0.46	0.41	0.28

*Calf weight estimation based on 1.80 lbs average daily gain and 95 lbs birth weight.

Table 8. Pasture-forage feed costs per production period and supplement costs by 12-month management strategy.

		12.0 M Repeated Seasonal	6.0 M Seasonlong	4.5 M Seasonlong	4.0 M Deferred	4.5 M Twice-over Rotation
Dry Gestation	$	37.44	13.12	13.12	14.20	5.12
Third Trimester	$	130.50	46.80	46.80	46.80	18.90
Early Lactation	$	85.05	45.00	33.75	33.75	13.50

Spring Lactation	$	41.85	18.40	16.47	36.44	15.95
Summer Lactation	$	98.64	158.55	111.25		78.84
Early	$	18.40			77.79	
Fall Lactation	$		35.39	13.26		12.00
Late	$	21.90				
Total Forage Feed Cost	$	433.78	317.26	234.65	208.98	144.31
Supplement Cost	$	36.98	12.25	11.50	11.16	26.69
Total Feed Cost	$	470.76	329.51	246.15	220.14	171.00

Table 9. Cost per pound of calf weight by 12-month management strategy.

		12.0 M Repeated Seasonal	**6.0 M Seasonlong**	**4.5 M Seasonlong**	**4.0 M Deferred**	**4.5 M Twice-over Rotation**
Cost/lb Birth Wt	$	1.58	0.59	0.59	0.59	0.36
Cost/lb Calf Gain						
Early Lactation	$	1.09	0.42	0.42	0.42	0.21
Spring Lactation	$		0.64	0.27	0.27	0.24
Summer Lactation	$	0.54	0.64	0.39	0.35	0.26
Fall Lactation	$		1.99	1.05	0.85	0.23
Cost/lb Accumulated Wt	$	0.64	0.59	0.40	0.34	0.25
Cost/lb Weaning Wt	$	0.88	0.61	0.46	0.41	0.28

*Based on estimated calf weight

Table 10. Projection of returns for production from 300 cows by 12-month management strategy.

	12.0 M Repeated Seasonal	**6.0 M Seasonlong**	**4.5 M Seasonlong**	**4.0 M Deferred**	**4.5 M Twice-over Rotation**

# Cows	#	300	300	300	300	300
Acres/12-month	ac	14,874	8,178	7,179	4,728	3,504
Total Feed Costs	$	141,228	98,853	73,845	66,042	51,300
Calf Weight Value @ $0.70/lb	$	111,804	113,064	113,109	112,590	126,759
Net Return	$	-29,424	14,211	39,264	46,548	75,459

Table 11. Projection of returns for production from 5,000 acres by 12-month management strategy.

		12.0 M Repeated Seasonal	6.0 M Seasonlong	4.5 M Seasonlong	4.0 M Deferred	4.5 M Twice-over Rotation
# Cows	#	100	183	209	317	428
Acres/12-month	ac	5,000	5,000	5,000	5,000	5,000
Total Feed Costs	$	47,076	60,300	51,445	69,784	73,188
Calf Weight Value @ $0.70/lb	$	37,268	68,969	78,799	118,970	180,843
Net Return	$	-9,808	8,669	27,354	49,186	107,655

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