Twelve-Month Forage Management Strategy Development and Evaluation

Twelve-month forage management strategies are developed by selection of a pasture forage type or a harvested forage type for use during each range cow production period. The combined sequence of assembled forage types composes a 12-month forage management strategy.

Twelve-month forage management strategy development that is based on traditional concepts treat livestock as the source of revenue and forage as the feedstuffs livestock eat. Traditional forage management strategies emphasize the use of land as feed for livestock and promote minimal use of harvested forages. Traditional selection criteria for forage types are based on the quantity of forage dry matter weight per acre and on low cash flow costs or low production costs per acre.

Twelve-month forage management strategy development that is based on biologically effective concepts treat forage crude protein produced on the land resources as the source of new wealth generation and the beef weight produced as the commodity sold at market. Biologically effective management strategies emphasize meeting plant biological requirements and promote stimulation of vegetative reproduction by tillering and enhancement of rhizosphere organism activity and the biogeochemical processes in the ecosystem. Biologically effective selection criteria for forage types are based on low forage feed costs per day, low forage crude protein costs per pound, low calf weight gain costs per pound, small land areas per cow, and high returns after feed costs per acre.

Pasture Forage Types

Results

The 12-month repeated seasonal management strategy (table 64) was developed from herbage biomass data collected monthly from ungrazed plots. This traditionally based strategy was evaluated as a sequence of six separate native rangeland pastures grazed at the proper stocking rate, with each pasture grazed repeatedly on consecutive years during one designated production period, and not grazed during any other production periods. A reserved native rangeland pasture was used during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was low and the crude protein content of the pasture forage was below the dietary requirements of the cow with 1.6 pounds of supplemental crude protein provided. A large land area of 5.33 acres per cow was required. Even though the production costs per acre were low, reserved native rangeland pastures grazed during the dry gestation production period were high-cost forage with very high forage feed costs per day, very high forage crude protein costs per pound, and extremely high calf weight gain costs per pound. The returns after feed costs were a high loss per cow and a moderate loss per acre (table 64).

A reserved native rangeland pasture was used during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was low and the crude protein content of the pasture forage was below the dietary requirements of the cow with 38.7 pounds of supplemental crude protein provided. A large land area of 18.62 acres per cow was required. Even though the production costs per acre were low, reserved native rangeland pastures grazed during the third trimester production period were high-cost forage with extremely high forage feed costs per day, extremely high forage crude protein costs per pound, and extremely high calf weight gain costs per pound. The returns after feed costs were an extremely high loss per cow and a moderate loss per acre (table 64).

The calves were born in mid March. A reserved native rangeland pasture was used during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was very low and the crude protein content of the pasture forage was below the dietary requirements of the cow, during which, no supplemental crude protein was provided. A large land area of 10.80 acres per cow was required. Even though the production costs per acre were low, reserved native rangeland pastures grazed during the early lactation production period were high-cost forage with extremely high forage feed costs per day, very high forage crude protein costs per pound, and very high calf weight gain costs per pound. The returns after feed costs were a very high loss per cow and a moderate loss per acre (table 64).

A native rangeland pasture was used during the spring lactation production period for 31 days from early May to late May. Native grass plants are not physiologically ready for grazing during May. The forage dry matter yield per acre was low and the quantity of crude protein captured per acre was low. A large land area of 4.77 acres per cow was required.

Even though the production costs per acre were low, native rangeland pastures grazed during the spring lactation production period before grass plants produce three and a half new leaves were high-cost forage with very high forage feed costs per day, high forage crude protein costs per pound, and high calf weight gain costs per pound. The returns after feed costs were a moderate loss per cow and a low loss per acre (table 64).

A native rangeland pasture was used during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was moderate and the crude protein content of the pasture forage was adequate for about 61 days and below the dietary requirements of the cow for about 76 days, during which, no supplemental crude protein was provided. A large land area of 11.32 acres per cow was required. Even though the production costs per acre were low, a single native rangeland pasture grazed during the summer lactation production period was moderate-cost forage with high forage feed costs per day, moderate forage crude protein costs per pound, and moderately high calf weight gain costs per pound. The returns after feed costs were high per cow and low per acre (table 64).

A native rangeland pasture was used during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was low and the crude protein content of the pasture forage was below the dietary requirements of the cow with 36.3 pounds of supplemental crude protein provided. A large land area of 4.60 acres per cow was required. Even though the production costs per acre were low, a native rangeland pasture grazed during the fall lactation production period was high-cost forage with extremely high forage feed costs per day, very high forage crude protein costs per pound, and very high calf weight gain costs per pound. The returns after feed costs were a high loss per cow and a moderate loss per acre (table 64). The calves were weaned in mid November.

The 12-month repeated seasonal management strategy with native rangeland and reserved native rangeland pastures was a high-cost forage management strategy (table 64). The 12-month forage feed costs at \$1.39 per day were very high, the 12-month forage crude protein costs at \$0.62 per pound were very high, and the 12-month calf weight gain costs at \$0.95 per pound were very high. The 12-month land area per cow at 55.44 acres was extremely large. The 12-month returns after feed costs at \$-133.61 per cow was an extremely high loss and at \$-2.41 per acre was a moderate loss (table 69). The 12-month repeated seasonal management strategy has no harvested forage feeds; the cattle graze six different pastures during the year. There are no equipment costs or labor costs charged to the forage feed costs. And yet, this management strategy has the highest forage feed costs per day, the highest forage crude protein costs per pound, the highest calf weight gain costs per pound, and the largest land area per cow. The returns after feed costs were the greatest loss per cow and the greatest loss per acre (tables 69 and 77). The elimination of equipment costs, labor costs, and harvested forage costs does not reduce beef production costs and improve profit margins.

The reserved native rangeland pastures grazed during the nongrowing season of the repeated seasonal management strategy gave the false impression of being low cost forage because the production costs per acre were low and no harvested forage was fed. However, because the forage dry matter yield per acre was about 40% of the forage dry matter yield during the summer period, the weight of crude protein capture per acre was about 20% to 25% of the crude protein capture per acre during the summer period, and the land area required per cow was greater than 2.5 times the land area required per cow during the summer period, the forage from the reserved pastures was high-cost. The cost of the forage was greater than the low market value of the calf weight accumulated during the nongrowing season resulting in a high loss of \$191.40 per cow and a high loss of \$5.51 per acre. Additional financial losses were derived as a result of the decision to use the pastures as reserved forage during the nongrowing season rather than to use the pastures as metabolically active forage during the growing season, which in effect, prevented the capture of the potential new wealth generated from the land resources. The potential revenue that could be captured from the forage crude protein produced on the land and available during the summer period ranges between \$40 and \$133 per cow and between \$2 and \$15 per acre depending on the management treatment implemented. This potential new wealth generated from the land resources that was not captured during the growing season was a major loss that should be considered when developing management plans that include reserved native rangeland pastures grazed during the nongrowing season.

The 6.0-month seasonlong management strategy is a simple traditional combination of a native rangeland pasture with a complementary reserved native rangeland pasture and mature crested wheatgrass hay (table 65). A reserved native rangeland pasture was grazed during the dry gestation production period for

32 days from mid November to mid December. The forage dry matter yield per acre was low and the crude protein content of the pasture forage was below the dietary requirements of the cow with 1.6 pounds of supplemental crude protein provided. A large land area of 5.33 acres per cow was required. Even though the production costs per acre were low, reserved native rangeland pastures grazed during the dry gestation production period were high-cost forage with very high forage feed costs per day, very high forage crude protein costs per pound, and extremely high calf weight gain costs per pound. The returns after feed costs were a high loss per cow and a moderate loss per acre (table 65).

Mature crested wheatgrass hay was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 30.1 pounds of supplemental crude protein provided. A small land area of 1.35 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the third trimester production period was moderate-cost forage with moderate forage feed costs per day, high forage crude protein costs per pound, and high calf weight gain costs per pound. The returns after feed costs were very low per cow and very low per acre (table 65).

The calves were born in mid March. Mature crested wheatgrass hay was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 45.0 pounds of supplemental crude protein provided. A small land area of 0.76 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the early lactation production period was moderate-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 65).

Mature crested wheatgrass hay was fedduring the early portion of the spring lactation production period for 15 days from early May to mid May. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 8.9 pounds of supplemental crude protein provided. A small land area of 0.28 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the first half of the spring lactation production period was high-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderately low calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 65).

Grazing on a single native rangeland pasture started early in mid May before the grass plants had produced three and a half new leaves. The native rangeland pasture was grazed during the latter portion of the spring lactation production period for 16 days from mid May to late May. Continuation of feeding the high-cost mature crested wheatgrass hay for an additional 16 days would have been lower cost than starting grazing native rangeland too early. Native grass plants are not physiologically ready for grazing during May. The forage dry matter yield per acre was low and the quantity of crude protein captured per acre was low. A large land area of 2.10 acres per cow was allotted. Even though the production costs per acre were low, a native rangeland pasture grazed during the latter half of the spring lactation production period was high-cost forage with very high forage feed costs per day, high forage crude protein costs per pound, and high calf weight gain costs per pound. The returns after feed costs were very low per cow and extremely low per acre (table 65).

Grazing was continued on the single native rangeland pasture during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was moderate and the crude protein content of the pasture forage was adequate for about 61 days and below the dietary requirements of the cow for about 76 days, during which, no supplemental crude protein was provided. A large land area of 18.10 acres per cow was allotted. Even though the production costs per acre were low, a single native rangeland pasture grazed during the summer lactation production period was high-cost forage with very high forage feed costs per day, very high forage crude protein costs per pound, and high calf weight gain costs per pound. The returns after feed costs were high per cow and very low per acre (table 65).

Grazing continued on the single native rangeland pasture during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was low and the crude protein content of the pasture forage was below the dietary requirements of the cow, during which, no supplemental crude protein was provided. Even though the production costs per acre were low, native rangeland pasture grazed during the fall lactation production period was very high-cost forage with very high forage feed costs per day, very high forage crude protein costs per pound, and extremely high calf weight gain costs per pound. The returns after feed costs were a high loss per cow and a moderate loss per acre (table 65). The calves were weaned in mid November.

The 12-month 6.0-month seasonlong management strategy with a native rangeland pasture and a complementary reserved native rangeland pasture and mature crested wheatgrass hay was a high-cost forage management strategy (table 65). The 12-month forage feed costs at $0.96 per day were high, the 12-month forage crude protein costs at $0.47 per pound were high, and the 12-month calf weight gain costs at $0.65 per pound were high. The 12-month land area per cow at 31.96 acres was very large. The 12-month returns after feed costs at $25.83 per cow was moderately low and at $0.81 per acre was extremely low (table 69).

The deferred grazing management strategy is a traditional combination of delayed use of a native rangeland pasture with complementary crested wheatgrass and cropland aftermath pastures and mature crested wheatgrass hay (table 66). A cropland aftermath pasture was grazed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter available per acre was very low and the quantity of crude protein captured per acre was extremely low with the crude protein content of the pasture forage below the dietary requirements of the cow, during which, no supplemental crude protein was provided. A large land area of 7.10 acres per cow was allotted. Even though the production costs per acre were very low, cropland aftermath pasture of annual cereal stubble grazed during the dry gestation production period was high-cost forage with low forage feed costs per day, very high forage crude protein costs per pound, and moderately high calf weight gain costs per pound. The returns after feed costs were low per cow and extremely low per acre (table 66). The lost cow weight was the major cost from grazing cropland aftermath forage.

Mature crested wheatgrass hay was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 30.1 pounds of supplemental crude protein provided. A small land area of 1.35 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the third trimester production period was moderate-cost forage with moderate forage feed costs per day, high forage crude protein costs per pound, and high calf weight gain costs per pound. The returns after feed costs were very low per cow and very low per acre (table 66).

The calves were born in mid March. Mature crested wheatgrass hay was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 45.0 pounds of supplemental crude protein provided. A small land area of 0.76 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the early lactation production period was moderate-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 66).

An unfertilized crested wheatgrass pasture was grazed during the spring lactation production period for 31 days from early May to late May. Grazing was extended on this single unfertilized crested wheatgrass pasture for an additional 45 days during the early portion of the summer lactation production period from early June to mid July. The forage dry matter yield per acre was moderate and the crude protein content of the pasture forage was adequate for about 51 days until the third week in June and below the dietary requirements of the cow for about 25 days, during which, no supplemental crude protein was provided. A small land area of 4.16 acres per cow was allotted. The stocking rate for this treatment was too high and the seasonal period of use was too long for the plants and livestock to sustain production at these high reported levels. The production costs per acre were low and an unfertilized crested wheatgrass pasture grazed during the spring lactation and early summer lactation production periods was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderately high per cow and moderate per acre (table 66). However, this pasture forage management treatment as conducted and reported is not sustainable.

A native rangeland pasture was delay grazed during the latter portion of the summer lactation production period for 92 days from mid July to mid October. The forage dry matter yield per acre was moderate and the crude protein content of the pasture forage was adequate for about 16 days and below the dietary requirements of the cow for about 76 days, during which, no supplemental crude protein was provided. A moderate land area of 6.70 acres per cow was allotted. The stocking rate for this treatment was too high for the plants and livestock to sustain production at these high reported levels. The production costs per acre were very low and a native rangeland pasture grazed during the late summer lactation production period was high-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderately low calf weight gain costs per pound. The returns after feed costs were high per cow and moderate per acre (table 66). However, this pasture forage management treatment as conducted and reported is not sustainable.

Grazing continued on the single native rangeland pasture during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was low and the crude protein content of the pasture forage was below the dietary requirements of the cow, during which, no supplemental crude protein was provided. A moderate land area of 2.18 acres per cow was allotted. The stocking rate for this pasture was too high for the forage available during the summer period and this high stocking rate was not adjusted downward to match the reduction in aboveground forage dry matter during the fall period. Even though the production costs per acre were very low, a native rangeland pasture grazed during the fall lactation production period was high-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and very high calf weight gain costs per pound. The returns after feed costs were a moderate loss per cow and a moderate loss per acre (table 66). The calves were weaned in mid November.

The 12-month deferred grazing management strategy with a native rangeland pasture and complementary crested wheatgrass and cropland aftermath pastures and mature crested wheatgrass hay was a high-cost forage management strategy (table 66). The 12-month forage feed costs at $0.58 per day were moderate, the 12-month forage crude protein costs at $0.31 per pound were high, and the 12-month calf weight gain costs at $0.39 per pound were moderate. The 12-month land area per cow at 22.25 acres was large but too small for a 1200 pound cow with calf. The 12-month returns after feed costs at $164.91 per cow was moderate and at $7.41 per acre was low (table 69).

The 4.5-month seasonlong management strategy is a traditional combination of a native rangeland pasture with complementary crested wheatgrass and cropland aftermath pastures and mature crested wheatgrass hay and oat forage hay cut late (table 67). Mature crested wheatgrass hay was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was adequate to meet the dietary requirements of the cow with 19.2 pounds of supplemental roughage provided. A small land area of 0.47 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the dry gestation production period was moderate-cost forage with low forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and low per acre (table 67).

Oat forage hay cut late was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was adequate to meet the dietary requirements of the cow. A small land area of 0.38 acres per cow was required. Even though the production costs per acre were high, late cut oat forage hay fed during the third trimester production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 67).

The calves were born in mid March. Oat forage hay cut late was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was below the dietary requirements of the cow with 27.9 pounds of supplemental crude protein provided. A small land area of 0.21 acres per cow was required. Even though the production costs per acre were high, late cut oat forage hay fed during the early lactation production period was low-cost forage with moderate forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were high per cow and very high per acre (table 67).

An unfertilized crested wheatgrass pasture was grazed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was high and the crude protein content of the pasture forage was adequate to meet the dietary requirements of the cow. A small land area of

1.88 acres per cow was required. The production costs per acre were low and an unfertilized crested wheatgrass pasture grazed during the spring lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 67).

A native rangeland pasture was grazed during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was moderate and the crude protein content of the pasture forage was adequate for about 61 days and below the dietary requirements of the cow for about 76 days, during which, no supplemental crude protein was provided. A large land area of 12.70 acres per cow was allotted. Even though the production costs per acre were very low, a single native rangeland pasture grazed seasonlong during the summer lactation production period was high-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderately low calf weight gain costs per pound. The returns after feed costs were high per cow and low per acre (table 67).

A cropland aftermath pasture was grazed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was low and the extremely low crude protein content of the pasture forage was below the dietary requirements of the cow, during which, no supplemental crude protein was provided. A large land area of 6.63 acres per cow was allotted. Even though the production costs per acre were low and the land rent per acre was very low, a cropland aftermath pasture of annual cereal stubble grazed during the fall lactation production period was high-cost forage with low forage feed costs per day, very high forage crude protein costs per pound, and very high calf weight gain costs per pound. The returns after feed costs were a moderate loss per cow and a low loss per acre (table 67). The calves were weaned in mid November.

The 12-month 4.5-month seasonlong management strategy with a native rangeland pasture and complementary crested wheatgrass and cropland aftermath pastures and mature crested wheatgrass hay and oat forage hay cut late was a moderate-cost forage management strategy (table 67). The 12-month forage feed costs at $0.57 per day were moderate, the 12-month forage crude protein costs at $0.30 per pound were high, and the 12-month calf weight gain costs at $0.39 per pound were moderate. The 12-month land area per cow at 22.27 acres was large. The 12-month returns after feed costs at $169.38 per cow was moderate and at $7.61 per acre was low (table 69).

The twice-over rotation management strategy is a combination of biologically effective forage types identified to have low forage feed costs and to efficiently capture high value from the land natural resources. The biologically effective strategy consists of a three native rangeland pasture rotation system with complementary crested wheatgrass and Altai wildrye pastures and forage barley hay cut early (table 68). Forage barley hay cut early was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 400.0 pounds of supplemental roughage provided. A very small land area of 0.08 acres per cow was required. Even though the production costs per acre were high, early cut forage barley hay fed during the dry gestation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and high per acre (table 68).

Forage barley hay cut early was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 864.0 pounds of supplemental roughage provided. A small land area of 0.27 acres per cow was required. Even though the production costs per acre were high, early cut forage barley hay fed during the third trimester production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 68).

The calves were born in mid March. Forage barley hay cut early was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 270.0 pounds of supplemental roughage provided. A very small land area of 0.20 acres per cow was required. Even though the production costs per acre were high, early cut forage barley hay fed during the early lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were high per cow and extremely high per acre (table 68).

A fertilized (50 lbs N/acre applied during the first week of April) crested wheatgrass pasture was grazed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was high and the crude protein content of the pasture forage was high. A small land area of 0.75 acres per cow was required. The production costs per acre were moderate and a fertilized crested wheatgrass pasture grazed during the spring lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 68).

Each of three native rangeland pastures were grazed for two periods during the summer lactation production period for 137 days from early June to mid October. The first grazing period of 15 days occurred between 1 June and 15 July (when lead tillers of grasses were between the three and a half new leaf stage and the flowering stage) and the second grazing period of 30 days occurred after 15 July and prior to mid October (when the secondary tillers of grasses had reached the third leaf stage). The first pasture grazed in the sequence was the last pasture grazed the previous year. The forage dry matter yield per acre was high and the high crude protein content of the pasture forage was adequate to meet the dietary requirements of the cow for about 122 days and was marginal to below the requirements for 15 days or less. A small land area of 9.00 acres per cow was required. The production costs per acre were low and three to six native rangeland pastures grazed in rotation during the summer lactation production period were low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were very high per cow and high per acre (table 68).

An Altai wildrye pasture was grazed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was high and the relatively high crude protein content of the pasture forage was adequate to meet the dietary requirements of the cow for most of the grazing period and marginal or slightly below the requirements during the latter portion of the period. A small land area of 1.39 acres per cow was required when the pasture had a high plant population. The production costs per acre were low and Altai wildrye pastures grazed during the fall lactation production period were low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 68). The calves were weaned in mid November.

The 12-month twice-over rotation management strategy with native rangeland pastures and complementary crested wheatgrass and Altai wildrye pastures and early cut forage barley hay was a low-cost forage management strategy (table 68). The 12-month forage feed costs at \$0.47 per day were low, the 12-month forage crude protein costs at \$0.15 per pound were low, and the 12-month calf weight gain costs at \$0.28 per pound were very low. The 12-month land area per cow at 11.69 acres was small. The 12-month returns after feed costs at \$251.36 per cow was very high and at \$21.50 per acre was high (table 69). The 12-month twice-over rotation management strategy does not have the lowest forage feed costs per day; it does not have the lowest forage crude protein costs per pound; it does not have the lowest calf weight gain costs per pound; it does not have the smallest land area per cow; and it does not have the greatest returns after feed costs per acre (tables 69 and 77). However, all of the critical cost factors were below the threshold values and this management strategy does have the greatest returns after feed costs per cow-calf pair (table 68).

Discussion

Traditionally managed pasture forage types provide forage dry matter feed at or near the cows requirements, however, crude protein is often deficient. The biologically effective twice-over rotation strategy is managed to provide both forage dry matter and crude protein at the dietary requirements of the cow. The availability of sufficient crude protein for range cows at the required times and in the required amounts was different among the 12-month pasture forage management strategies (table 70). The crude protein content of the forage feed provided to the range cows was deficient for 298 days (82%) on the deferred grazing, 288 days (79%) on the 6.0-month seasonlong, 273 days (75%) on the repeated seasonal, 151 days (41%) on the 4.5-month seasonlong, and 15 days (4%) on the twice-over rotational management strategies. Supplemental crude protein was provided during 182 days (50%) on the 6.0-month seasonlong, 152 days (42%) on the repeated seasonal, 135 days (37%) on the deferred grazing, 45 days (12%) on the 4.5-month seasonlong, and 0 days (0%) on the twice-over rotation management strategies. Crude protein was deficient in the forage and not provided as supplement for 163 days (45%) on the deferred grazing, 121 days (33%) on the repeated seasonal, 106 days (29%) on the 6.0-month seasonlong, 106 days (29%) on the 4.5-month seasonlong, and 15 days or less (4%) on the twice-over rotation management strategies (table 70).

Crude protein deficiency in range cow diets greatly affects cow and calf weight performance and the quantity of calf weight produced per acre. Calf weight gain was 9.60 lb/ac on the repeated seasonal, 16.89 lb/ac on the 6.0-month seasonlong, 24.10 lb/ac on the deferred grazing, 24.19 lb/ac on the 4.5-month seasonlong, and 51.64 lb/ac on the twice-over rotation management strategies. The number of days per year that range cow forage feed is deficient in crude protein affects the weight of crude protein captured per acre and, in return, the quantity of new wealth generated from the land resources per acre. The returns after feed costs were $-2.41/ac on the repeated seasonal, $0.81/ac on the 6.0-month seasonlong, $7.41/ac on the deferred grazing, $7.61/ac on the 4.5-month seasonlong, and $21.50/ac on the twice-over rotation management strategies (table 69).

Modern, high-performance cattle have greater nutrient demand than old-style cattle and modern cattle perform at greater efficiency when their nutritional demands are met during each production period. Management strategies developed for old-style low-performance cattle were based on the traditional concepts of providing adequate forage dry matter at a low cash flow cost or a low production cost per acre. The traditional management strategies of repeated seasonal, 6.0-month seasonlong, deferred grazing, and 4.5-month seasonlong provided adequate quantities of forage dry matter that were deficient in crude protein for 41% to 82% of the days per year and even though supplemental crude protein was provided during some deficiency periods, the diets of the range cows were deficient in crude protein for 45% to 29% of the days per year. Using old-style traditional forage management strategies to provide forage feed for modern cattle results in low calf weight gain per acre and low returns after feed costs per acre.

Management strategies based on biologically effective concepts use forage types during their growth stages in which adequate crude protein and adequate dry matter are available to range cows at low forage feed costs per day and low forage crude protein costs per pound. The twice-over rotation management strategy efficiently captures a high proportion of the forage produced crude protein and generates considerable new wealth from the land resources per acre.

Harvested Forage Types

Results

Harvested forage management strategies were developed by using one harvested forage type during all of the range cow production periods. These management strategies were evaluated during a 12-month period not as designs for actual forage systems but to demonstrate that harvested forages are not always the high-cost forage they are assumed to be and to show that substantial revenue can be captured per acre by feeding harvested forage types. A 12-month management strategy comprised entirely of harvested forage types would include two or more forage types that would work together in a cropland rotation, such as, early cut forage barley hay and late cut pea forage hay seeded separately. An obvious practical application of 12-month harvested forage management strategies would be for the beef production operation that desires to expand the size of the cow herd but, for some reason, can not expand the size of the land base. The 12-month harvested forage management strategies provide a mechanism by which stockmen can produce relatively low-cost forage and feed for a greater number of cows on a smaller land base per cow.

Another practical application of 12-month harvested forage management strategies would be to provide low-cost forage for beef cow herds with calf birth dates at unconventional times. Cow herds with conventional calf birth dates (January through April) can efficiently capture low-cost forage from domesticated and native range perennial grasses when grazing and cutting are properly coordinated with plant growth stages. However, with grazing, the herbage growth curves and nutritional quality curves of perennial grasses can not be effectively matched biologically with the nutrient requirements for cows with unconventional calf birth dates. The resulting inefficiency of nutrient capture would increase the costs of livestock feed and the costs of calf accumulated weight. Feed costs for cow herds with unconventional calf birth dates could be reduced with the use of low-cost annual cereal and annual legume hays harvested at their optimum plant growth stages.

The 12-month mature crested wheatgrass hay management strategy harvested the hay forage at the plant growth stage that captured the greatest quantity of forage dry matter per acre. Mature crested wheatgrass hay was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was adequate to meet the dietary requirements of the cow with 19.2 pounds of supplemental roughage provided. A small land area of 0.47 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the dry gestation production period was moderate-cost forage with low forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and low per acre (table 71).

Mature crested wheatgrass hay was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 30.1 pounds of supplemental crude protein provided. A small land area of 1.35 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the third trimester production period was moderate-cost forage with moderate forage feed costs per day, high forage crude protein costs per pound, and high calf weight gain costs per pound. The returns after feed costs were very low per cow and very low per acre (table 71).

The calves were born in mid March. Mature crested wheatgrass hay was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 45.0 pounds of supplemental crude protein provided. A small land area of 0.76 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the early lactation production period was moderate-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 71).

Mature crested wheatgrass hay was fed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 18.29 pounds of supplemental crude protein provided. A small land area of 0.58 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the spring lactation production period was high-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 71).

Mature crested wheatgrass hay was fed during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 80.83 pounds of supplemental crude protein provided. A small land area of 2.57 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the summer lactation production period was high-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were high per cow and moderate per acre (table 71).

Mature crested wheatgrass hay was fed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was below the dietary requirements of the cow with 17.70 pounds of supplemental crude protein provided. A small land area of 0.56 acres per cow was required. The production costs per acre were moderate and mature crested wheatgrass hay fed during the fall lactation production period was high-cost forage with high forage feed costs per day, high forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 71). The calves were weaned in mid November.

The 12-month mature crested wheatgrass hay management strategy was a high-cost forage management strategy (table 71). The 12-month forage feed costs at $0.64 per day were high, the 12-month forage crude protein costs at $0.28 per pound were high, and the 12-month calf weight gain costs at $0.41 per pound were moderate. The 12-month land area per cow at 6.29 acres was small. The 12-month returns after feed costs at $168.54 per cow was moderate and at $26.79 per acre was moderate (table 77).

The 12-month crested wheatgrass hay cut early management strategy harvested the hay forage at the plant growth stage that captured the greatest quantity of forage crude protein per acre. Crested wheatgrass hay cut early was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was moderate with 438.4 pounds of supplemental roughage provided. A small land area of

0.26 acres per cow was required. The production costs per acre were moderate and early cut crested wheatgrass hay fed during the dry gestation production period was moderate-cost forage with moderate forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and moderate per acre (table 72).

Crested wheatgrass hay cut early was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was moderate with 999.0 pounds of supplemental roughage provided. A small land area of 0.89 acres per cow was required. The production costs per acre were moderate and early cut crested wheatgrass hay fed during the third trimester production period was moderate-cost forage with moderate forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 72).

The calves were born in mid March. Crested wheatgrass hay cut early was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was moderate with 369.0 pounds of supplemental roughage provided. A small land area of 0.65 acres per cow was required. The production costs per acre were moderate and early cut crested wheatgrass hay fed during the early lactation production period was moderate-cost forage with moderate forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 72).

Crested wheatgrass hay cut early was fed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was moderate with 393.7 pounds of supplemental roughage provided. A small land area of 0.41 acres per cow was required. The production costs per acre were moderate and early cut crested wheatgrass hay fed during the spring lactation production period was moderate-cost forage with moderate forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 72).

Crested wheatgrass hay cut early was fed during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was moderate with 1739.9 pounds of supplemental roughage provided. A small land area of 1.82 acres per cow was required. The production costs per acre were moderate and early cut crested wheatgrass hay fed during the summer lactation production period was moderate-cost forage with moderate forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were very high per cow and high per acre (table 72).

Crested wheatgrass hay cut early was fed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was moderate and the crude protein content of the harvested forage was moderate with 381.0 pounds of supplemental roughage provided. A small land area of 0.40 acres per cow was required. The production costs per acre were moderate and early cut crested wheatgrass hay fed during the fall lactation production period was moderate-cost forage with moderate forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 72). The calves were weaned in mid November.

The 12-month crested wheatgrass hay cut early management strategy was a moderate-cost forage management strategy (table 72). The 12-month forage feed costs at $0.53 per day were moderate, the 12-month forage crude protein costs at $0.14 per pound were low, and the 12-month calf weight gain costs at $0.33 per pound were low. The 12-month land area per cow at 4.43 acres was small. The 12-month returns after feed costs at $211.48 per cow was high and at $47.74 per acre was high (table 77).

The 12-month forage barley hay cut early management strategy harvested the hay forage at the plant growth stage that captured the greatest quantity of forage crude protein per acre. Forage barley hay cut early was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 400.0 pounds of supplemental roughage provided. A very small land area of 0.08 acres per cow was required. The production costs per acre were high and early cut forage barley hay fed during the dry gestation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and high per acre (table 73).

Forage barley hay cut early was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 864.0 pounds of supplemental roughage provided. A small land area of 0.27 acres per cow was required. The production costs per acre were high and early cut forage barley hay fed during the third trimester production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 73).

The calves were born in mid March. Forage barley hay cut early was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 270.0 pounds of supplemental roughage provided. A very small land area of 0.20 acres per cow was required. The production costs per acre were high and early cut forage barley hay fed during the early lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were high per cow and extremely high per acre (table 73).

Forage barley hay cut early was fed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 331.7 pounds of supplemental roughage provided. A very small land area of 0.13 acres per cow was required. The production costs per acre were high and early cut forage barley hay fed during the spring lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were moderate per cow and extremely high per acre (table 73).

Forage barley hay cut early was fed during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 1465.9 pounds of supplemental roughage provided. A small land area of 0.56 acres per cow was required. The production costs per acre were high and early cut forage barley hay fed during the summer lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were very high per cow and extremely high per acre (table 73).

Forage barley hay cut early was fed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 321.0 pounds of supplemental roughage provided. A very small land area of 0.12 acres per cow was required. The production costs per acre were high and early cut forage barley hay fed during the fall lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were moderate per cow and extremely high per acre (table 73). The calves were weaned in mid November.

The 12-month forage barley hay cut early management strategy was a low-cost forage management strategy (table 73). The 12-month forage feed costs at $0.43 per day were low, the 12-month forage crude protein costs at $0.11 per pound were very low, and the 12-month calf weight gain costs at $0.27 per pound were very low. The 12-month land area per cow at 1.36 acres was very small. The 12-month returns after feed costs at $246.83 per cow was very high and at $181.49 per acre was extremely high (table 77).

The 12-month oat forage hay cut early management strategy harvested the hay forage at the plant growth stage that captured the greatest quantity of forage crude protein per acre. Oat forage hay cut early was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 352.0 pounds of supplemental roughage provided. A very small land area of 0.09 acres per cow was required. The production costs per acre were high and early cut oat forage hay fed during the dry gestation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and high per acre (table 74).

Oat forage hay cut early was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 693.0 pounds of supplemental roughage provided. A small land area of 0.31 acres per cow was required. The production costs per acre were high and early cut oat forage hay fed during the third trimester production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 74).

The calves were born in mid March. Oat forage hay cut early was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 148.5 pounds of supplemental roughage provided. A very small land area of 0.23 acres per cow was required. The production costs per acre were high and early cut oat forage hay fed during the early lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were high per cow and very high per acre (table 74).

Oat forage hay cut early was fed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 254.2 pounds of supplemental roughage provided. A very small land area of 0.14 acres per cow was required. The production costs per acre were high and early cut oat forage hay fed during the spring lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were moderate per cow and extremely high per acre (table 74).

Oat forage hay cut early was fed during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 1123.4 pounds of supplemental roughage provided. A small land area of 0.64 acres per cow was required. The production costs per acre were high and early cut oat forage hay fed during the summer lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were very high per cow and extremely high per acre (table 74).

Oat forage hay cut early was fed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 246.0 pounds of supplemental roughage provided. A very small land area of 0.14 acres per cow was required. The production costs per acre were high and early cut oat forage hay fed during the fall lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and very low calf weight gain costs per pound. The returns after feed costs were moderate per cow and extremely high per acre (table 74). The calves were weaned in mid November.

The 12-month oat forage hay cut early management strategy was a low-cost forage management strategy (table 74). The 12-month forage feed costs at $0.43 per day were low, the 12-month forage crude protein costs at $0.13 per pound were low, and the 12-month calf weight gain costs at $0.27 per pound were very low. The 12-month land area per cow at 1.55 acres was very small. The 12-month returns after feed costs at $245.47 per cow was very high and at $158.37 per acre was very high (table 77).

The 12-month pea forage hay cut late management strategy harvested the hay forage at the plant growth stage that captured the greatest quantity of forage crude protein per acre. Pea forage hay cut late was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 438.4 pounds of supplemental roughage provided. A very small land area of 0.07 acres per cow was required. The production costs per acre were high and late cut pea forage hay fed during the dry gestation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and high per acre (table 75).

Pea forage hay cut late was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 990.0 pounds of supplemental roughage provided. A small land area of 0.25 acres per cow was required. The production costs per acre were high and late cut pea forage hay fed during the third trimester production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and high per acre (table 75).

The calves were born in mid March. Pea forage hay cut late was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 360.0 pounds of supplemental roughage provided. A very small land area of 0.18 acres per cow was required. The production costs per acre were high and late cut pea forage hay fed during the early lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were high per cow and extremely high per acre (table 75).

Pea forage hay cut late was fed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 390.6 pounds of supplemental roughage provided. A very small land area of 0.12 acres per cow was required. The production costs per acre were high and late cut pea forage hay fed during the spring lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and extremely high per acre (table 75).

Pea forage hay cut late was fed during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 1726.2 pounds of supplemental roughage provided. A small land area of 0.51 acres per cow was required. The production costs per acre were high and late cut pea forage hay fed during the summer lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were very high per cow and extremely high per acre (table 75).

Pea forage hay cut late was fed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 378.0 pounds of supplemental roughage provided. A very small land area of 0.11 acres per cow was required. The production costs per acre were high and late cut pea forage hay fed during the fall lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and extremely high per acre (table 75). The calves were weaned in mid November.

The 12-month pea forage hay cut late management strategy was a low-cost forage management strategy (table 75). The 12-month forage feed costs at $0.50 per day were low, the 12-month forage crude protein costs at $0.13 per pound were low, and the 12-month calf weight gain costs at $0.32 per pound were low. The 12-month land area per cow at 1.24 acres was very small. The 12-month returns after feed costs at $219.81 per cow was high and at $177.27 per acre was extremely high (table 77).

The 12-month forage lentil hay cut late management strategy harvested the hay forage at the plant growth stage that captured the greatest quantity of forage crude protein per acre. Forage lentil hay cut late was fed during the dry gestation production period for 32 days from mid November to mid December. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 444.8 pounds of supplemental roughage provided. A very small land area of 0.09 acres per cow was required. The production costs per acre were high and late cut forage lentil hay fed during the dry gestation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were low per cow and high per acre (table 76).

Forage lentil hay cut late was fed during the third trimester production period for 90 days from mid December to mid March. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 1017.0 pounds of supplemental roughage provided. A small land area of 0.30 acres per cow was required. The production costs per acre were high and late cut forage lentil hay fed during the third trimester production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and moderate calf weight gain costs per pound. The returns after feed costs were moderate per cow and moderate per acre (table 76).

The calves were born in mid March. Forage lentil hay cut late was fed during the early lactation production period for 45 days from mid March to late April. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 378.0 pounds of supplemental roughage provided. A very small land area of 0.22 acres per cow was required. The production costs per acre were high and late cut forage lentil hay fed during the early lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were high per cow and very high per acre (table 76).

Forage lentil hay cut late was fed during the spring lactation production period for 31 days from early May to late May. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 399.9 pounds of supplemental roughage provided. A very small land area of 0.14 acres per cow was required. The production costs per acre were high and late cut forage lentil hay fed during the spring lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and very high per acre (table 76).

Forage lentil hay cut late was fed during the summer lactation production period for 137 days from early June to mid October. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 1767.3 pounds of supplemental roughage provided. A small land area of 0.60 acres per cow was required. The production costs per acre were high and late cut forage lentil hay fed during the summer lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were very high per cow and extremely high per acre (table 76).

Forage lentil hay cut late was fed during the fall lactation production period for 30 days from mid October to mid November. The forage dry matter yield per acre was high and the crude protein content of the harvested forage was high with 387.0 pounds of supplemental roughage provided. A very small land area of 0.13 acres per cow was required. The production costs per acre were high and late cut forage lentil hay fed during the fall lactation production period was low-cost forage with low forage feed costs per day, low forage crude protein costs per pound, and low calf weight gain costs per pound. The returns after feed costs were moderate per cow and extremely high per acre (table 76). The calves were weaned in mid November.

The 12-month forage lentil hay cut late management strategy was a low-cost forage management strategy (table 76). The 12-month forage feed costs at $0.51 per day were low, the 12-month forage crude protein costs at $0.13 per pound were low, and the 12-month calf weight gain costs at $0.32 per pound were low. The 12-month land area per cow at 1.48 acres was very small. The 12-month returns after feed costs at $217.88 per cow was high and at $147.22 per acre was very high (table 77).

Discussion

Some harvested forages are expensive, but not all harvested forages are high-cost feeds. Harvested forages cut at plant growth stages that yield great amounts of crude protein per acre have low costs per pound of crude protein and are low-cost forage feeds that efficiently capture high value from the land natural resources. Harvested forages cut at plant growth stages that yield great amounts of forage dry matter and low amounts of crude protein per acre have high costs per pound of crude protein and are high-cost forage feeds that only generate a small portion of the potential new wealth from the land resources.

Traditionally, domesticated perennial grass hays from crested wheatgrass and smooth bromegrass are cut late after the seed heads have developed and plants have reached maximum height. This practice yields about the year's potential amount of forage dry matter per acre at a moderately low cost per ton, but the low yield in weight of crude protein per acre causes high crude protein costs per pound and high forage feed costs per day. Mature crested wheatgrass hay has lower returns after feed costs per acre than crested wheatgrass hay cut early at the boot stage because early cut crested wheatgrass hay captures nearly double the pounds of crude protein per acre. Forage barley and oat forage hays cut early at the milk stage and pea forage and forage lentil hays cut late capture greater crude protein yield per acre and have greater returns after feed costs per acre than forage barley and oat forage hays cut late at the hard dough stage and pea forage and forage lentil hays cut early, respectively.

Management Implications

Evaluation of the costs of the pasture forage and harvested forage types that compose 12-month forage management strategies has shown that these costs are largely determined by the biological effectiveness and crude protein capture and conversion efficiency of the management strategy. Reduction of forage feed costs requires implementation of management strategies that are biologically effective at stimulation of vegetative tillering and rhizosphere organism activity and are efficient at crude protein capture per acre and efficient at conversion of forage crude protein to a saleable product like calf weight. These biological and nutritional aspects of 12-month forage management strategies can be increased through the improvement of four factors.

- increasing herbage and crude protein production per acre 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 crude protein capture efficiency by timing grazing and harvest periods to remove greater amounts of crude protein per acre rather than greater amounts of forage dry matter. Supplementation of dry matter roughage is lower cost than supplementation of crude protein.
- increasing nutrient conversion efficiency by providing adequate crude protein throughout the range cows' 12-month production cycle because high-performance livestock perform at greater efficiencies when not limited by periods with crude protein deficiency.
- increasing forage feed management system efficiency by combining pasture types and harvested forage types in a 12-month sequence so that the herbage production curves and crude protein quality curves are coordinated with the 12-month dietary quantity and quality requirement curves of range cow production periods.

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

Beef production is the last meat industry to improve the efficiency of forage feed management systems. The traditional 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 the forage feed management strategies have not been adjusted to provide crude protein 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 forage feed for high-performance livestock to produce high profit margins. Biologically effective management strategies efficiently capture high proportions of the forage produced crude protein and generate considerable new wealth from the land natural resources.

Acknowledgment

I am grateful to Sheri Schneider for assistance in production of this manuscript and for development of the tables.

Table 64. Summary of 12-month pasture forage and harvested forage management strategy: Repeated Seasonal on native rangeland and reserved native rangeland pastures.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Repeated Seasonal								
Forage Type			Reserved Native Rangeland			Native Rangeland		
Land Area	ac	5.33	18.62	10.80	4.77	11.32	4.60	55.44
Crude Protein	$/lb	1.01	1.26	0.76	0.28	0.25	0.92	0.62
Forage Feed Cost	$	47.23	174.73	94.64	41.85	98.64	51.20	508.29
Cost/Day	$	1.48	1.94	2.10	1.35	0.72	1.71	1.39
Acc. Calf Wt.	lb	24.92	70.08	81.00	55.80	246.60	54.00	532.40
Return/c-cpr	$	-27.79	-125.67	-37.94	-2.79	73.98	-13.40	-133.61
Return/acre	$	-5.59	-6.75	-3.51	-0.58	6.54	-2.91	-2.41
Cost/lb Calf Gain	$	1.90	2.49	1.17	0.75	0.40	0.95	0.95

Table 65. Summary of 12-month pasture forage and harvested forage management strategy:
6.0-month Seasonlong on native rangeland with reserved native rangeland pastures and mature crested wheatgrass hay.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation		Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	15 d	16 d	137 d	30 d	365 d
6.0-month Seasonlong									
Forage Type		Reserved Native Range		Mature Crested Wheatgrass Hay			Native Range	Native Range	
Land Area	ac	5.33	1.35	0.76	0.28	2.10	18.10	4.04	31.96
Crude Protein	$/lb	1.01	0.28	0.28	0.28	0.28 est	0.52 est	0.82	0.47
Forage Feed Cost	$	47.23	47.04	34.91	10.65	18.40	158.55	35.39	352.17
Cost/Day	$	1.48	0.52	0.78	0.71	1.15	1.16	1.18	0.96
Acc. Calf Wt.	lb	24.92	70.08	85.50	30.00	28.80	282.87	17.73	539.90
Return/c-cpr	$	-29.79	2.02	24.94	10.42	1.76	39.46	-22.98	25.83
Return/acre	$	-5.59	1.50	32.82	37.14	0.83	2.18	-5.69	0.81
Cost/lb Calf Gain	$	1.90	0.67	0.41	0.35	0.64	0.56	1.99	0.65

Table 66. Summary of 12-month pasture forage and harvested forage management strategy: Deferred Grazing on native rangeland with complementary crested wheatgrass and cropland aftermath pastures and mature crested wheatgrass hay.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	76 d	92 d	30 d	365 d
Deferred Grazing								
Forage Type		Cropland Aftermath	Mature Crested Wheatgrass Hay		Unfertilized Crested Wheatgrass	Native Rangeland		
Land Area	ac	7.10	1.35	0.76	4.16	6.70	2.18	22.25
Crude Protein	$/lb	0.74	0.28	0.28	0.13 est.	0.28 est.	0.44	0.31
Forage Feed Cost	$	14.20	47.04	34.91	36.44	58.26	19.53	210.38
Cost/Day	$	0.44	0.52	0.78	0.48	0.63	0.65	0.58
Acc. Calf Wt.	lb	24.92	70.08	85.50	136.04	196.50	23.10	536.14
Return/c-cpr	$	3.24	2.02	24.94	58.78	79.29	-3.36	164.91
Return/acre	$	0.46	1.50	32.82	14.13	11.83	-1.51	7.41
Cost/lb Calf Gain	$	0.57	0.67	0.41	0.27	0.30	0.85	0.39

Table 67. Summary of 12-month pasture forage and harvested forage management strategy:
4.5-month Seasonlong on native rangeland with complementary crested wheatgrass and cropland aftermath pastures and mature crested wheatgrass hay and oat forage hay cut late.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
4.5-month Seasonlong								
Forage Type		Mature Crested Wheatgrass Hay	Oat Forage Hay cut late		Unfertilized Crested Wheatgrass	Native Range	Cropland Aftermath	
Land Area	ac	0.47	0.38	0.21	1.88	12.70	6.63	22.27
Crude Protein	$/lb	0.28	0.17	0.17	0.11	0.37 est.	0.74 est.	0.30
Forage Feed Cost	$	13.46	28.80	24.41	16.47	111.25	13.26	207.65
Cost/Day	$	0.42	0.32	0.54	0.52	0.81	0.44	0.57
Acc. Calf Wt.	lb	24.92	70.08	85.50	59.21	286.33	12.57	538.61
Return/c-cpr	$	3.98	20.26	35.44	24.98	89.18	-4.46	169.38
Return/acre	$	8.47	53.32	168.76	13.29	7.02	-0.67	7.61
Cost/lb Calf Gain	$	0.54	0.41	0.29	0.27	0.39	1.05	0.39

Table 68. Summary of 12-month pasture forage and harvested forage management strategy:
Twice-over Rotation on native rangeland with complementary crested wheatgrass and Altai wildrye pastures and forage barley hay cut early.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Twice-over Rotation								
Forage Type			Forage Barley Hay cut early		Fertilized Crested Wheatgrass	Native Range	Altai Wildrye	
Land Area	ac	0.08	0.27	0.20	0.75	9.00	1.39	11.69
Crude Protein	$/lb	0.11	0.11	0.11	0.10 est.	0.20 est.	0.16 est.	0.15
Forage Feed Cost	$	12.12	33.86	18.23	15.95	78.84	12.18	171.18
Cost/Day	$	0.38	0.38	0.41	0.51	0.58	0.40	0.47
Acc. Calf Wt.	lb	24.92	70.08	85.50	67.58	302.77	52.77	603.62
Return/c-cpr	$	5.32	15.20	41.62	31.36	133.10	24.76	251.36
Return/acre	$	66.50	56.30	208.10	41.82	14.79	17.81	21.50
Cost/lb Calf Gain	$	0.49	0.48	0.21	0.24	0.26	0.23	0.28

Table 69. Summary of costs and returns after feed costs per acre for 12-month pasture forage management strategies.

12-month Management Strategies	Forage Feed Costs $/d	Calf Weight Costs $/lb	Crude Protein Costs $/lb	Land Area acre/c-cpr	Returns After Feed Costs $/acre
Repeated Seasonal	1.39	0.95	0.62	55.44	-2.41
6.0-m Seasonlong	0.96	0.65	0.47	31.96	0.81
Deferred Grazing	0.58	0.39	0.31	22.25	7.41
4.5-m Seasonlong	0.57	0.39	0.30	22.27	7.61
Twice-over Rotation	**0.47**	**0.28**	**0.15**	**11.69**	**21.50**

Bolded management strategies meet the selection criterion and efficiently capture high value from the land natural resources.

Table 70. Availability of sufficient crude protein for range cows on 12-month pasture forage management strategies.

12-month Management Strategies	Forage with Adequate Crude Protein		Forage Deficient in Crude Protein		Crude Protein Supplementation Provided		Crude Protein Supplementation Not Provided	
	Days	% of 12-mo	Days	% of 12-mo	Days	% of 12-mo	Days	% of 12-mo
Repeated Seasonal	92	25%	273	75%	152	42%	121	33%
6.0-m Seasonlong	77	21%	288	79%	182	50%	106	29%
Deferred Grazing	67	18%	298	82%	135	37%	163	45%
4.5-m Seasonlong	214	59%	151	41%	45	12%	106	29%
Twice-over Rotation	350	96%	15	4%	0	0%	15	4%

Table 71. Summary of 12-month pasture forage and harvested forage management strategy: Mature Crested Wheatgrass Hay.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Mature Crested Wheatgrass Hay								
Forage Type				Mature Crested Wheatgrass Hay				
Land Area	ac	0.47	1.35	0.76	0.58	2.57	0.56	6.29
Crude Protein	$/lb	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Forage Feed Cost	$	13.46	47.04	34.91	21.86	96.59	21.15	235.01
Cost/Day	$	0.42	0.52	0.78	0.71	0.71	0.71	0.64
Acc. Calf Wt.	lb	24.92	70.08	85.50	62.00	274.00	60.00	576.50
Return/c-cpr	$	3.98	2.02	24.94	21.54	95.21	20.85	168.54
Return/acre	$	8.47	1.50	32.82	37.14	37.05	37.07	26.79
Cost/lb Calf Gain	$	0.54	0.67	0.41	0.35	0.35	0.35	0.41

Table 72. Summary of 12-month pasture forage and harvested forage management strategy: Crested Wheatgrass Hay cut early.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Crested Wheatgrass Hay cut early								
Forage Type					Crested Wheatgrass Hay cut early			
Land Area	ac	0.26	0.89	0.65	0.41	1.82	0.40	4.43
Crude Protein	$/lb	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Forage Feed Cost	$	14.40	40.88	23.53	17.73	78.37	17.16	192.07
Cost/Day	$	0.45	0.45	0.52	0.57	0.57	0.57	0.53
Acc. Calf Wt.	lb	24.92	70.08	85.50	62.00	274.00	60.00	576.50
Return/c-cpr	$	3.04	8.18	36.32	25.67	113.43	24.84	211.48
Return/acre	$	11.69	9.19	55.88	62.61	62.32	62.10	47.74
Cost/lb Calf Gain	$	0.58	0.58	0.28	0.29	0.29	0.29	0.33

Table 73. Summary of 12-month pasture forage and harvested forage management strategy: Forage Barley Hay cut early.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Forage Barley Hay cut early								
Forage Type				Forage Barley Hay cut early				
Land Area	ac	0.08	0.27	0.20	0.13	0.56	0.12	1.36
Crude Protein	$/lb	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Forage Feed Cost	$	12.12	33.86	18.23	14.48	64.01	14.02	156.72
Cost/Day	$	0.38	0.38	0.41	0.47	0.47	0.47	0.43
Acc. Calf Wt.	lb	24.92	70.08	85.50	62.00	274.00	60.00	576.50
Return/c-cpr	$	5.32	15.20	41.62	28.92	127.79	27.98	246.83
Return/acre	$	66.50	56.30	208.10	222.46	228.20	233.17	181.49
Cost/lb Calf Gain	$	0.49	0.48	0.21	0.23	0.23	0.23	0.27

Table 74. Summary of 12-month pasture forage and harvested forage management strategy: Oat Forage Hay cut early.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Oat Forage Hay cut early								
Forage Type				Oat Forage Hay cut early				
Land Area	ac	0.09	0.31	0.23	0.14	0.64	0.14	1.55
Crude Protein	$/lb	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Forage Feed Cost	$	12.24	33.73	18.35	14.68	64.87	14.21	158.08
Cost/Day	$	0.38	0.37	0.41	0.47	0.47	0.47	0.43
Acc. Calf Wt.	lb	24.92	70.08	85.50	62.00	274.00	60.00	576.50
Return/c-cpr	$	5.20	15.33	41.50	28.72	126.93	27.79	245.47
Return/acre	$	57.78	49.45	180.43	205.14	198.33	198.50	158.37
Cost/lb Calf Gain	$	0.49	0.48	0.21	0.24	0.24	0.24	0.27

Table 75. Summary of 12-month pasture forage and harvested forage management strategy: Pea Forage Hay cut late.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Pea Forage Hay cut late								
Forage Type					Pea Forage Hay cut late			
Land Area	ac	0.07	0.25	0.18	0.12	0.51	0.11	1.24
Crude Protein	$/lb	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Forage Feed Cost	$	13.75	38.93	22.05	17.07	75.42	16.52	183.74
Cost/Day	$	0.43	0.43	0.49	0.55	0.55	0.55	0.50
Acc. Calf Wt.	lb	24.92	70.08	85.50	62.00	274.00	60.00	576.50
Return/c-cpr	$	3.69	10.13	37.80	26.33	116.38	25.48	219.81
Return/acre	$	52.71	40.52	210.00	219.42	228.20	231.64	177.27
Cost/lb Calf Gain	$	0.55	0.56	0.26	0.28	0.28	0.28	0.32

Table 76. Summary of 12-month pasture forage and harvested forage management strategy: Forage Lentil Hay cut late.

		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation	12-month Season
Days		32 d	90 d	45 d	31 d	137 d	30 d	365 d
Forage Lentil Hay cut late								
Forage Type				Forage Lentil Hay cut late				
Land Area	ac	0.09	0.30	0.22	0.14	0.60	0.13	1.48
Crude Protein	$/lb	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Forage Feed Cost	$	13.86	39.40	22.37	17.23	76.14	16.67	185.67
Cost/Day	$	0.43	0.44	0.50	0.56	0.56	0.56	0.51
Acc. Calf Wt.	lb	24.92	70.08	85.50	62.00	274.00	60.00	576.50
Return/c-cpr	$	3.58	9.66	37.48	26.17	115.66	25.33	217.88
Return/acre	$	39.78	32.20	170.36	186.93	192.77	194.85	147.22
Cost/lb Calf Gain	$	0.56	0.56	0.26	0.28	0.28	0.28	0.32

Table 77. Summary of costs and returns after feed costs per acre for 12-month harvested forage management strategies.

12-month Management Strategies	Forage Feed Costs $/d	Calf Weight Costs $/lb	Crude Protein Costs $/lb	Land Area acre/c-cpr	Returns After Feed Costs $/acre
Crested Wheat, mature	0.64	0.41	0.28	6.29	26.79
Crested Wheat, early	**0.53**	**0.33**	**0.14**	**4.43**	**47.74**
Forage Barley, early	**0.43**	**0.27**	**0.11**	**1.36**	**181.49**
Oat Forage, early	**0.43**	**0.27**	**0.13**	**1.55**	**158.37**
Pea Forage, late	**0.50**	**0.32**	**0.13**	**1.24**	**177.27**
Forage Lentil, late	**0.51**	**0.32**	**0.13**	**1.48**	**147.22**

Bolded management strategies meet the selection criterion and efficiently capture high value from the land natural resources.

Literature Cited

Beard, L.W. 1998. 1998 North Dakota custom rates. North Dakota Agricultural Statistics Service. http://www.nass.usda.gov/nd/cus

Beef Cattle Resource Committee (BCRC). 1999. Beef Cattle Handbook. University of Wisconsin Cooperative Extension Publishing Unit. Midwest Plan Service. Ames, IA.

Carr, P. 1995. Western Dakota Crops Day Research Report. North Dakota State University.

Carr, P. 1996. Western Dakota Crops Day Research Report. North Dakota State University.

Carr, P. 1997. Western Dakota Crops Day Research Report. North Dakota State University.

Carr, P. 1998. Western Dakota Crops Day Research Report. North Dakota State University.

Carr, P. 1999. Western Dakota Crops Day Research Report. North Dakota State University.

Manske, L.L., and P.M. Carr. 2000. Determination of costs of harvested forage types to help reduce beef production costs. NDSU Dickinson Research Extension Center. Range Research Report DREC 00-1029. Dickinson, ND. 18p.

Manske, L.L. 1999a. Annual nutritional quality curves for domesticated cool-season grasses. NDSU Dickinson Research Extension Center. Range Mangement Report DREC 99-1024. Dickinson, ND. 13p.

Manske, L.L. 1999b. Annual nutritional quality curves for native range cool-season grasses. NDSU Dickinson Research Extension Center. Range Mangement Report DREC 99-1026. Dickinson, ND. 16p.

Manske, L.L. 1999c. Annual nutritional quality curves for native range warm-season grasses. NDSU Dickinson Research Extension Center. Range Mangement Report DREC 99-1027. Dickinson, ND. 13p.

Manske, L.L. 2001. Pasture and forage costs-returns of twelve-month management strategies for range cows. NDSU Dickinson Research Extension Center. Range Research Report DREC 01-1040. Dickinson, ND. 22p.

Manske, L.L. 2002. Pasture and forage costs of grazingland and harvested forages for range cows. NDSU Dickinson Research Extension Center. Range Research Report DREC 02-1045. Dickinson, ND. 11p.

Manske, L.L. 2003a. Cow and calf performance as affected by grazing management. NDSU Dickinson Research Extension Center. Range Research Report DREC 03-1052. Dickinson, ND. 28p.

Manske, L.L. 2003b. Cow and calf performance on pasture forage types during Fall, mid October to mid November. NDSU Dickinson Research Extension Center. Range Research Report DREC 03-1054. Dickinson, ND. 14p.

Manske, L.L. 2003c. A method of determining stocking rate based on monthly standing herbage biomass. Range Program Information Sheet #31. NDSU Dickinson Research Extension Center. 6p.

Manske, L.L. 2004. Annual cereal fall pasture strategies. NDSU Dickinson Research Extension Center. Range Research Report DREC 04-1055. Dickinson, ND. 9p.

Manske, L.L. 2007. Restoration of degraded prairie ecosystems. NDSU Dickinson Research Extension Center. Summary Range Management Report DREC 07-3045. Dickinson, ND. 6p.

National Research Council (NRC). 1996. Nutrient requirements of beef cattle. 7th rev. ed. National Academy Press, Washington, DC.

Nelson, J.L., W. Poland, and G. Ottmar. 2002. Utilization of extended grazing periods to increase the net value of cow/calf enterprises. 2001 Annual Report. NDSU Dickinson Research Extension Center. Dickinson, ND. p.183-189.

Swenson, A., and R. Haugen. 1999. Projected 2000 crop budgets for southwest North Dakota. NDSU Extension Service. http://www.ext.nodak.edu/extpubs/agecon/

Whitman, W.C., D.W. Bolin, E.W. Klosterman, H.J. Klostermann, K.D. Ford, L. Moomaw, D.G. Hoag, and M.L. Buchanan. 1951. Carotine, protein, and phosphorus in range and tame grasses of western North Dakota. North Dakota Agricultural Experiment Station. Bulletin 370. Fargo, ND. 55p.