Increasing Value Captured from the Land Natural Resources: An Evaluation of Pasture Forage and Harvested Forage Management Strategies for Each Range Cow Production Period

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The purpose of this research project is to identify the factors that affect livestock pasture forage and harvested forage costs and to determine which factors can be controlled by management to improve profit margins from the production of beef and to increase the new wealth generated from the land natural resource without depletion of future production.

The three major areas of investment for a beef operation are the land, the cattle, and the labor and equipment. The natural tendency for agricultural producers to focus on the product sold at market has placed an industry wide priority on the livestock when management and economic decisions are made. This traditional approach assumes the livestock to be the source of revenue and the dry matter weight to be the sought after product from grazinglands and haylands for livestock forage feed. However, this long held paradigm has not reduced production costs nor increased income for beef producers.

Traditional management strategies for grazinglands and haylands concentrate on a single use of the land as feed for livestock, promote harvesting greater amounts of forage dry matter weight, and compensate for deficiencies in forage nutritional qualities with the practices of crude protein supplementation, creep feeding, and early weaning. These traditional practices are inherently inefficient at capturing forage produced nutrients and consequently they only generate a small portion of the potential new wealth from the land resources.

Forage dry matter does not have a real economic value because it is not incorporated into the beef weight produced. The dry matter is simply the carrier of the nutrients it contains; therefore, the cost of the forage dry matter is only indirectly related to forage feed costs. The nutrients are the valuable products produced by forage plants on the land. The cow processes the forage nutrients and produces milk resulting in calf weight accumulation. This calf weight is the commodity sold at the market, nevertheless, the original source of the income from the sale of beef weight is the forage nutrients. The renewable forage nutrients are the primary unit of production in a beef operation, and they are the source of new wealth from agricultural use of grazingland and hayland resources.

The major forage produced nutrients are energy (TDN) and crude protein. Crude protein is deficient in beef cattle forage based diets earlier in the growing season than energy. A pound of crude protein has a greater impact on the natural resources of an ecosystem to produce and a greater influence on the cost of livestock forage feed than the production of a pound of energy. The energy (TDN) produced by forage plants is part of the ecosystem's carbon cycle. Plants capture and fix carbon from atmospheric carbon dioxide with the hydrogen from soil water during the process of photosynthesis which converts energy from the sun into chemical energy. The assimilated carbon is combined in several ways to form various types of sugars and starches that are collectively called carbohydrates (CHO). These carbohydrates can be used as an energy source by the plant or by the herbivore that consumes plant parts. Capturing energy by fixing carbon has a relatively low impact on organisms that possess chlorophyll and on the ecosystem resources. The crude protein produced by forage plants is part of the ecosystem's nitrogen cycle. Inorganic nitrogen is taken up by plant roots from the surrounding rhizosphere and, through complex processes, the plant combines the inorganic nitrogen with carbon, hydrogen, and oxygen to synthesize different kinds of amino acids which are combined to produce various types of very large organic compounds called proteins. After parts of the plant are consumed by herbivores or parts of the plant die, the large nitrogenous compounds comprising the herbivore excreta or the dead plant material are broken down and converted from organic nitrogen into inorganic nitrogen through numerous complex stages by soil organisms in the rhizosphere. Transforming nitrogen from inorganic nitrogen to organic nitrogen and back to inorganic nitrogen is complex and has a great impact on many organisms at multiple trophic levels and on the ecosystem resources.

The quantity of new wealth generated from agricultural use of land resources is limited by the biological capacity of the forage plants to produce herbage and nutrients from soil, sunlight, water, and carbon dioxide and by the effectiveness of management treatments in capturing value from plant production. Increasing value captured from the land requires using management strategies that place priority on plant health and stimulate ecological biogeochemical processes, enhance vegetative plant growth, capture a high proportion of the produced nutrients, and efficiently convert these nutrients into saleable commodities such as calf weight.

The quantity of crude protein captured per acre as livestock feed is the factor that has the greatest influence on the costs of pasture forage and harvested forage and on the amount of new wealth generated from the land resources. The weight of crude protein captured per acre is related to the percent crude protein content and the weight of the forage dry matter at the time of grazing or haying. The cost per pound of crude protein is determined by the weight of the crude protein captured per acre prorated against the forage production costs which include the land costs, equipment costs, and labor costs per acre. Reductions in livestock feed costs result from capturing greater quantities of crude protein per acre. Capturing greater quantities of the produced crude protein from a land base causes a reduction in the amount of land area required to feed a cow-calf pair and results in lowering the forage feed costs because the forage production costs per acre are spread over a greater number of pounds of crude protein.

Reductions in forage dry matter costs, forage production costs, land rent costs, equipment costs, or labor costs may cause some reduction in cash expenditures but reductions in these costs do not directly regulate livestock forage feed costs because these costs do not respond proportionally to the variation in quantities of forage needed to provide livestock with adequate amounts of nutrients resulting from the differences in the weight of crude protein captured per acre through the grazing or haying of various forage types at different plant growth stages.

Generally, perennial and annual grass forages that are grazed or hayed at a mature plant stage, after flowering, are high-cost forages; the quantity of dry matter per acre is greater causing a reduction in production costs per ton of forage dry matter, however, the quantity of crude protein per acre is lower causing an increase in cost per pound of crude protein and requiring greater land area to provide adequate feed for a cow-calf pair resulting in an increase of forage feed costs. Perennial grass forages that are grazed or hayed at an early plant stage, after the three and a half new leaf stage and before flowering, and annual cereal forages that are cut between the boot stage and the milk stage are low-cost forages; the quantity of forage dry matter per acre is less causing an increase in production costs per ton of forage dry matter but the quantity of crude protein captured per acre is greater causing a decrease in cost per pound of crude protein and requiring less land area to provide adequate feed for a cow-calf pair resulting in a decrease of forage feed costs.

Generally, legume forages yield the greatest weight of crude protein per acre when the plants are at full growth but before the leaves start drying from senescence. The cost per pound of crude protein is lower for legume forages when plants are cut one time per year during a late full-growth stage resulting in lower forage feed costs. Legume forages cut at early plant growth stages yield higher crude protein percentages but because the weight of the crude protein captured per acre is lower, the cost per pound of crude protein is higher and the forage feed costs are higher.

Selection of pasture forage types and harvested forage types that effectively increase new wealth generated from land natural resources and reduce forage feed costs during each range cow production period can be made through comparisons of the cost per pound of captured crude protein, cost per day of forage feed, cost per pound of calf weight gain, land area required per cow-calf pair, and returns after feed costs per acre. Counterintuitively, comparisons of the traditional evaluation criteria of forage dry matter costs, forage production costs, land rent costs, equipment costs, or labor costs do not identify pasture forage types and harvested forage types that provide low forage feed costs.

This study uses forage feed production costs and returns after feed costs to compare and evaluate pasture forage types and harvested forage types during range cow production periods. This study is not a complete economic analysis of total livestock production costs or a study in livestock marketing schemes.

A positive profit margin can be achieved for a 12-month period from the production of beef during a low market cycle with calf weight valued at $0.70 per pound at weaning time when the forage feed costs average $0.62 or less per day, captured crude protein costs average $0.25 or less per pound, and calf weight gain costs average $0.42 or less per pound.

Procedure

This study determines and compares forage feed costs and returns after feed costs of pasture forage types and harvested forage types during range cow production periods. Production periods were differentiated when there was a change in cow nutrient requirements or a change in forage type use resulting from biological variations in plant growth curves. The 12-month range cow production cycle included the development and growth of a calf starting from late middle gestation in mid November through birth in mid March and continuing until weaning during the consecutive mid November.

The format of this report is intended to assist beef producers with the evaluation of the pasture forage and harvested forage management practices that they currently use and to assist in the development of efficient and biologically effective pasture forage and harvested forage strategies that reduce forage feed costs, increase returns after feed costs, and increase new wealth captured from the land resources.

Pasture forage and harvested forage costs of feed to meet range cow dry matter and crude protein requirements and the resulting net returns after feed costs per cow-calf pair and per acre were determined for each of the different range cow production periods 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 captured crude protein per acre; then, production costs per acre were divided by pounds of captured crude protein per acre.

Grazingland area per cow-calf pair per month and per production period were determined in two stages: first, pounds of forage dry matter per acre were divided by pounds of forage dry matter required per cow-calf pair per day to derive number of grazing days per acre; then, the average number of days per month (30.5d) or the number of days per production period was divided by the number of grazing days per acre. Pasture forage costs per production period was determined by multiplying the acres of grazingland per cow-calf pair per production period by the production cost per acre.

Harvested forage land area per cow-calf pair per production period was determined in two stages: first, pounds of crude protein required per cow per day during the production period were divided by percentage of crude protein of forage type to derive pounds of forage dry matter to provide as feed per cow-calf pair 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 the number of days per production period. Harvested forage cost per production period was determined by multiplying the pounds of harvested forage to feed per cow-calf pair per production period by the harvested forage cost per pound.

Roughage supplementation costs per production period were determined in three stages: first, the pounds of harvested forage to feed per cow-calf pair per day were subtracted from the pounds of harvested forage allocation per cow-calf pair per day; next, the pounds of roughage supplementation to feed per cow-calf pair per day was multiplied by the number of days per production period; then, the pounds of roughage supplement per period was multiplied by the market cost of the roughage per pound.

Crude protein supplementation costs per production period were determined in three stages: first, the pounds of crude protein provided by the forage allocation per day was subtracted from the pounds of crude protein required per cow per day; next, the pounds of crude protein supplementation to feed per cow-calf pair per day was multiplied by the number of days per production period; then, the pounds of crude protein supplement per period was multiplied by the market cost of the crude protein per pound.

Total feed cost per production period were determined by the sum of the pasture or harvested forage costs and the roughage or crude protein supplementation costs per production period. The total feed costs per production period were divided by the number of days per production period to determine the total feed cost per day.

Dollar value of calf weight gain per production period was 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, calf weight gain per period was multiplied by an assumed low market value of $0.70 per pound. The low market value of $0.70 per pound was used to evaluate and identify pasture forage and harvested forage types that would produce positive returns after feed costs during low portions in the cattle cycle. Net returns after feed costs per cow-calf pair was determined by subtracting the total feed costs per production period from the dollar value of calf weight gain per production period. Net returns after feed costs per acre was determined by dividing the net returns after feed costs per cow-calf pair per production period by the number of acres per cow-calf pair per period. Costs per pound of calf weight gain per production period were determined by dividing the total feed costs per production period by the pounds of calf weight accumulated per period.

The terms "herbage" and "forage" are not synonymous. Herbage is the total amount of aboveground biomass of herbaceous plants like grasses and forbs. Forage is the portion of the herbage that can be removed without detriment to the plants and can provide feed for grazing animals or be harvested mechanically for feeding. About 50% of the herbage produced by a perennial plant on grazinglands must remain with the plant to sustain healthy and productive growth. About 50% of the herbage biomass produced during the growing season can be removed from the plant without harmful effects to plant health. The amount of forage ingested by grazing livestock is actually only about 50% of this quantity, or about 25% of the aboveground herbage biomass on seasonlong and single-grazing-period treatments. The remainder of the herbage that can be removed is broken from the plant, soiled by animal waste, consumed by insects and wildlife, and lost to other natural processes.

Forage plants in pastures saved for grazing during fall and winter are categorized as reserved forage in this study. Some articles in the popular press have incorrectly used the term "stockpiled forage" to refer to late-season pastures. The word "stockpile" is not correctly used in reference with natural resources or living organisms. Manufactured products, like steel pipe, charcoal briquets, diesel fuel, lumber, and processed food, can be stockpiled at storage locations during periods of surplus and used later in their original prestored condition during periods of deficiency. Natural resources, like iron ore, lignite coal, and crude oil deposits, that are left in place as raw material until needed for manufacturing products are reserves, not stockpiles. Living organisms, like trees in a forest and fish in the ocean, that are left in place until needed and continue biological processes of life, growth, and death are reserves, not stockpiles. Perennial grass resources that are left in place and saved as unprocessed pasture forage until needed in fall and winter are living organisms that continue to change their dry matter weight and nutritional quality during the growing season and the nongrowing season and are, therefore, reserves, not stockpiles. The term "stockpiled forage" can correctly be used to refer only to processed forages that do not change in dry matter or nutrient content during storage.

Base Line Forage and Livestock Data

The base line pasture forage and harvested forage data and cow and calf weight performance data used in the current study to determine 12-month range cow production period forage feed costs and returns after forage costs were developed from numerous pasture forage and harvested forage management research projects conducted at the NDSU Dickinson Research Extension Center, located in western North Dakota.

Herbage weight for pasture forage types (tables 1-5) were based on the means of the average monthly herbage biomass data (Manske 2003c) collected by the clipping method during the period grazed on pasture management treatments involved in grazingland research projects conducted between 1983 and 1998 (Manske 2001). Forage dry matter weight was 25% of the pasture herbage weight (Manske 2003c). Percent crude protein data for native rangeland and crested wheatgrass forages during the period grazed (tables 1-5) were taken from Whitman et al. (1951) and Manske (1999a, b, c). Herbage weight data used in determination of stocking rates for the native rangeland repeated seasonal treatments were collected monthly from ungrazed plots (Manske 2001). Grazing dates and stocking rates for pasture forage types were means of data collected on the grazingland research projects (Manske 2001). Monthly herbage dry matter yield per acre on spring seeded winter cereal pastures (tables 1 and 5) was taken from Manske (2004). Herbage dry matter yield per acre on standing corn pastures (tables 1 and 2) was taken from Nelson et al. (2002).

Forage dry matter yield per acre and percent crude protein for annual crop varieties harvested as hay were collected on agronomic forage crop studies and reported annually (Carr 1995-1999). A summary of harvested forage production data for annual cereal and annual legume hays and perennial domesticated grass hay (table 6) were reported by Manske and Carr (2000).

Average production costs per acre for pasture forage types and harvested forage types (Manske 2002) were determined by adding applicable average land rent per acre from western North Dakota (table 8), average custom farm work rates (Beard 1998) (table 9), average seed costs per acre (Swenson and Haugen 1999) (table 10), and average custom baling rate per half ton of hay (table 9). Production costs do not include costs of fertilizer, pesticides, or transporting of feed, forages, and livestock unless specified. One pasture treatment of crested wheatgrass was fertilized annually with 50 pounds of nitrogen per acre at an average cost of $12.50 per acre. The pasture rent value of $8.76 per acre was used to determine costs for native rangeland and domesticated grassland grazingland (table 8). The value of $2.00 per acre was used for cropland aftermath grazing costs (table 8). 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 production costs for harvested forage types (table 8). Supplemental crude protein was provided as 20% crude protein range cake at a cost of $120.00 per ton ($0.30/lb CP). Supplemental forage dry matter was provided as roughage at a cost of $35.00 per ton ($0.0175/lb) (Manske 2001). Production costs per acre ($126.67), crude protein supplementation per day (0.54 lb/d), and feed costs per day ($1.23/d) for standing corn pastures were taken from Nelson et al. (2002).

Commercial Hereford and Angus-Hereford cows with calves were used on the pasture forage treatments. Individual animals were weighed on and off each treatment and at biweekly or monthly intervals during the grazing season. Average livestock weight data collected during a production period (tables 1-5) were used to determine cow and calf weight performance (Manske 2003a, b). Cow performance on spring seeded winter cereal pastures (tables 1 and 5) was taken from Manske (2004). Cow performance on standing corn pastures (tables 1 and 2) was taken from Nelson et al. (2002). Calf fetus weight gain was estimated to be 0.78 pounds per day from an average birth weight of 95 pounds accumulated over 122 days during the 32-day dry gestation period and the 90-day third trimester period (table 7). Calf weight gain on harvested forage treatments was estimated to be 1.90 pounds per day during the early lactation period and 2.00 pounds per day during spring, summer, and fall lactation periods (table 7).

Range cow daily nutritional requirements, which change with cow size, level of milk production, and production period (table 11) were taken from NRC (1996). Pasture forage dry matter allocation is a little greater than cow dry matter intake requirements. Daily dry matter allocation of pasture forage is 26 lbs for 1000 lb cows, 30 lbs for 1200 lb cows, and 33 lbs for 1400 lb cows (Manske 2003c) (table 12). Cow nutrient requirements change during the different production periods. The time of year during which the production periods occur is effected by the calf birth date. During this study, the dry matter and crude protein requirements for range cows with an average weight of 1200 lbs and an average calf birth date in mid March were used. The 12-month sequence of range cow production periods is shown in table 13. The dollar value of calf weight accumulated during each range cow production period was determined by the assumed low market price of $0.70 per pound.

Pasture Forage Types

The pasture forage types evaluated during the dry gestation production period were: native rangeland repeated seasonal, cropland aftermath, spring seeded winter cereal, and standing corn seasonal pastures. The pasture forage types evaluated during the third trimester production period were: native rangeland repeated seasonal and standing corn seasonal pasture. The pasture forage type evaluated during the early lactation production period was: native rangeland repeated seasonal. The pasture forage types evaluated during the spring lactation production period were: native rangeland repeated seasonal, 6.0-month seasonlong, crested wheatgrass unfertilized, crested wheatgrass extended use, and crested wheatgrass fertilized pastures. The pasture forage types evaluated during the summer lactation production period were: native rangeland repeated seasonal, 6.0-month seasonlong, 4.5-month seasonlong started early June, deferred grazing, and twice-over rotation management strategies. The pasture forage types evaluated during the fall lactation production period were: native rangeland repeated seasonal, 6.0-month seasonlong, 5.5-month seasonlong, deferred grazing, and 4.5-month seasonlong started mid June management strategies and Altai wildrye, cropland aftermath, and spring seeded winter cereal seasonal pastures.

Procedures to determine forage feed costs and returns after feed costs for pasture forage types during range cow production periods.

A. Select calf birth month:	mid March
B. Select cow size on 1 June:	1200 lbs
C. Select range cow production period:	table 13
D. Select pasture forage type:	tables 1-5
E. Complete the following steps	

1. Forage weight per acre is equal to
   mean monthly pasture herbage weight per acre during period grazed multiplied by 25% (tables 1-5).

2. Production cost per acre is equal to
   land rent per acre (table 8) plus any custom farm work costs (table 9).

3. Forage dry matter cost per pound is equal to
   production cost per acre (#2) divided by forage weight per acre (#1).

4. Forage dry matter cost per ton is equal to
   forage dry matter cost per pound (#3) multiplied by 2000 pounds (1 ton).

5. Crude protein weight per acre is equal to
   forage weight per acre (#1) multiplied by % crude protein of forage type (tables 1-5).

6. Crude protein cost per pound is equal to
   production cost per acre (#2) divided by pounds of crude protein per acre (#5).

7. Pounds of pasture forage allocation per cow-calf pair per day is equal to
   30 lb/d for 1200 lb cows (table 12).

8. Number of grazing days per acre on pasture forage types is equal to
   forage weight per acre (#1) divided by pounds of forage allocation per cow-calf pair per day (#7).

9. Acres of grazingland per cow-calf pair per month is equal to
   average number of days per month (30.5d) divided by number of grazing days per acre (#8).

10. Acres of grazingland per cow-calf pair per production period is equal to
    number of days per period (table 13) divided by number of grazing days per acre (#8).

11. Pasture forage cost per production period is equal to
    acres of grazingland per cow-calf pair per period (#10) multiplied by production cost per acre (#2).

12. Pounds of crude protein supplementation per day is equal to
    pounds of crude protein required per cow per day (table 11) minus (pounds of forage allocation per cow-calf pair per day (#7) multiplied by % crude protein of forage type (tables 1-5)).

13. Pounds of crude protein supplementation per production period is equal to
    pounds of crude protein supplementation per day (#12) multiplied by number of days per period (table 13).

14. Crude protein cost per production period is equal to
    pounds of crude protein supplementation per period (#13) multiplied by market cost of crude protein per pound ($0.30/lb CP).

15. Total feed costs per production period is equal to
    forage cost per period (#11 for pasture forage) plus supplementation costs per period (#14 for crude protein supplement).

16. Total feed costs per day is equal to
    total feed costs per production period (#15) divided by number of days per period (table 13).

17. Calf accumulated weight per production period is equal to
    weight of calf at end of period minus weight of calf at beginning of period (tables 1-5, calf gain/period).

18. Dollar value of calf weight per production period is equal to
    calf weight accumulated during production period (#17) multiplied by market price per pound ($0.70/lb).

19. Net returns after feed costs per cow-calf pair is equal to
    dollar value of calf weight per period (#18) minus total feed cost per period (#15).

20. Net returns after feed costs per acre is equal to
    net returns per cow-calf pair (#19) divided by number of acres per cow-calf pair per period (#10).

21. Cost per pound of calf weight gain per production period is equal to
    total feed costs per period (#15) divided by pounds of calf weight accumulated per period (#17).

Harvested Forage Types

The selected harvested forage types were evaluated during each range cow production period as hay cut by swathing and rolled into large round bales. Late crested wheatgrass hay was cut at a mature plant stage. Early crested wheatgrass hay was cut at the boot stage. Forage barley hay was cut both at the milk stage and at the hard dough stage. Oat forage hay was cut both at the milk stage and at the hard dough stage. Pea forage hay was cut at both early and late plant stages. Forage lentil hay was cut at both early and late plant stages. Oat-pea forage hay was cut at compromised plant stages of later than optimum for oat and earlier than optimum for pea.

Procedures to determine forage feed costs and returns after feed costs for harvested forage types during range cow production periods.

A. Select calf birth month:	mid March
B. Select cow size on 1 June:	1200 lbs
C. Select range cow production period:	table 13
D. Select harvested forage type:	table 6
E. Complete the following steps	

1. Forage weight per acre is equal to
   the harvested forage weight per acre removed by harvest methods (table 6).

2. Production cost per acre is equal to
   land rent per acre (table 8) plus custom farm work costs (table 9) plus seed cost per acre (table 10) plus baling cost [baling rate/1000 lbs (table 9) multiplied by (forage weight per acre (#1) divided by 1000 lbs (½ ton))].

3. Forage dry matter cost per pound is equal to
   production cost per acre (#2) divided by forage weight per acre (#1).

4. Forage dry matter cost per ton is equal to
   forage dry matter cost per pound (#3) multiplied by 2000 pounds (1 ton).

5. Crude protein weight per acre is equal to
   forage weight per acre (#1) multiplied by % crude protein of forage type (table 6).

6. Crude protein cost per pound is equal to
   production cost per acre (#2) divided by pounds of crude protein per acre (#5).

7. Pounds of harvested forage allocation per cow-calf pair per day is equal to
   pounds of dry matter intake required per cow per day (table 11) or use pounds of pasture forage allocation per cow-calf pair per day which is 30 lb/d for 1200 lb cows (table 12).

8. Pounds of harvested forage to feed per cow-calf pair per day is equal to
   pounds of crude protein intake required per cow per day (table 11) divided by % crude protein of forage type (table 6).

9. Pounds of harvested forage to feed per cow-calf pair per production period is equal to
   pounds of harvested forage to feed per day (#8) multiplied by number of days per period (table 13).

10. Acres of land harvested per cow-calf pair per production period is equal to
    pounds of harvested forage to feed per period (#9) divided by forage weight per acre (#1), (table 6, land area/period).

11. Harvested forage cost per production period is equal to
    pounds of harvested forage to feed per cow-calf pair per period (#9) multiplied by harvested forage cost per pound (#3).

12. Pounds of roughage supplementation per day is equal to
    pounds of harvested forage allocation per cow-calf pair per day (#7) minus pounds of harvested forage to feed per cow-calf pair per day (#8).

13. Pounds of roughage supplementation per production period is equal to
    pounds of roughage supplementation per day (#12) multiplied by number of days per period (table 13).

14. Roughage cost per production period is equal to
    pounds of roughage supplementation per period (#13) multiplied by market cost of roughage per pound ($0.0175/lb).

15. Pounds of crude protein supplementation per day is equal to
    pounds of crude protein required per cow per day (table 11) minus (pounds of forage allocation per cow-calf pair per day (#7) multiplied by % crude protein of forage type (table 6)).

16. Pounds of crude protein supplementation per production period is equal to
    pounds of crude protein supplementation per day (#15) multiplied by number of days per period (table 13).

17. Crude protein cost per production period is equal to
    pounds of crude protein supplementation per period (#16) multiplied by market cost of crude protein per pound ($0.30/lb).

18. Total feed costs per production period is equal to
    forage cost per period (#11) plus supplementation costs per period (#14 for roughage supplement) or (#17 for crude protein supplement).

19. Total feed costs per day is equal to
    total feed costs per production period (#18) divided by number of days per period (table 13).

20. Calf accumulated weight per production period is equal to
    weight of calf at end of period minus weight of calf at beginning of period (table 7).

21. Dollar value of calf weight is equal to
    calf weight accumulated during production period (#20) multiplied by market price per pound ($0.70/lb)

22. Net returns after feed costs per cow-calf pair is equal to
    dollar value of calf weight per period (#21) minus total feed cost per period (#18).

23. Net returns after feed costs per acre is equal to
    net returns per cow-calf pair (#22) divided by number of acres per cow-calf pair per period (#10).

24. Cost per pound of calf weight gain per production period is equal to
    total feed costs per period (#18) divided by pounds of calf weight accumulated per period (#20).

Table 1. Vegetation and livestock production values on pasture forage types during the dry gestation period.

	Native Rangeland Repeated Seasonal	Cropland Aftermath Seasonal Pasture	Spring Seeded Winter Cereal Seasonal Pasture	Standing Corn Seasonal Pasture
Production Period	Dry Gestation	Dry Gestation	Dry Gestation	Dry Gestation
Days	32	32	32	32
Herbage Wt. lb/ac	725	270	2487	9940
Forage Wt. lb/ac	180	135	1745	3840
Crude Protein %	4.8			
Crude Protein lb/ac	8.64			
Acres/Month ac	5.08	6.63	0.53	0.24
Acres/Period ac	5.33	7.10	0.56	0.25
Cow Gain/Day lb		-1.14	1.05	3.30
Cow Gain/Acre lb		-4.82	60.14	422.40
Cow Gain/Period lb		-36.48	33.68	105.60
Calf Gain/Day lb	0.78	0.78	0.78	0.78
Calf Gain/Acre lb	4.68	3.51	44.50	99.68
Calf Gain/Period lb	24.92	24.92	24.92	24.92

Table 2. Vegetation and livestock production values on pasture forage types during the third trimester and early lactation periods.

	Native Rangeland Repeated Seasonal	Standing Corn Seasonal Pasture	Native Rangeland Repeated Seasonal
Production Period	Third Trimester	Third Trimester	Early Lactation
Days	90	90	45
Herbage Wt. lb/ac	580	9940	480
Forage Wt. lb/ac	145	3840	125
Crude Protein %	4.8		9.2
Crude Protein lb/ac	6.96		11.50
Acres/Month ac	6.31	0.24	7.32
Acres/Period ac	18.62	0.70	10.80
Cow Gain/Day lb		0.86	
Cow Gain/Acre lb		110.57	
Cow Gain/Period lb		77.40	
Calf Gain/Day lb	0.78	0.78	1.80
Calf Gain/Acre lb	3.76	100.11	7.50
Calf Gain/Period lb	70.08	70.08	81.00

Table 3. Vegetation and livestock production values on pasture forage types during the spring lactation period.

		Native Rangeland Repeated Seasonal	Native Rangeland 6.0-m Seasonlong	Crested Wheatgrass Unfertilized	Crested Wheatgrass Unfertilized Extended Use	Crested Wheatgrass Fertilized
Production Period		Spring Lactation	Late Spring Lactation	Spring Lactation	Spring and Early Summer Lactation	Spring Lactation
Days		31	16	31	76	31
Herbage Wt.	lb/ac	780	906	1980	2192	4960
Forage Wt.	lb/ac	195	226	495	548	1240
Crude Protein	%	16.3		16.8		
Crude Protein	lb/ac	31.79		83.36		
Acres/Month	ac	4.62	4.04	1.82	1.67	0.73
Acres/Period	ac	4.77	2.10	1.88	4.16	0.75
Cow Gain/Day	lb		0.14	1.95	0.91	2.68
Cow Gain/Acre	lb		1.09	32.15	16.63	110.77
Cow Gain/Period	lb		2.30	60.45	69.16	83.08
Calf Gain/Day	lb	1.80	1.80	1.91	1.79	2.18
Calf Gain/Acre	lb	11.70	13.64	31.49	32.70	90.11
Calf Gain/Period	lb	55.80	28.80	59.21	136.04	67.58

Table 4. Vegetation and livestock production values on pasture forage types during the summer lactation period.

	Native Rangeland Repeated Seasonal	Native Rangeland 6.0-m Seasonlong	Native Rangeland 4.5-m Seasonlong	Native Rangeland Deferred Grazing	Native Rangeland Twice-over Rotation
Production Period	Summer Lactation	Summer Lactation	Summer Lactation	Late Summer Lactation	Summer Lactation
Days	137	137	137	92	137
Herbage Wt. lb/ac	1450	906	1280	1649	1794
Forage Wt. lb/ac	363	226	320	412	449
Crude Protein %	9.6				
Crude Protein lb/ac	34.85				
Acres/Month ac	2.52	4.04	2.86	2.22	2.04
Acres/Period ac	11.32	18.10	12.70	6.70	9.00
Cow Gain/Day lb		0.14	0.34	0.32	0.62
Cow Gain/Acre lb		1.09	3.67	4.40	9.44
Cow Gain/Period lb		19.66	46.58	29.44	84.94
Calf Gain/Day lb	1.80	1.80	2.09	1.80	2.21
Calf Gain/Acre lb	21.78	15.63	22.55	24.73	33.64
Calf Gain/Period lb	246.60	282.87	286.33	196.50	302.77

Table 5. Vegetation and livestock production values on pasture forage types during the fall lactation period.

	Native Rangeland Repeated Seasonal	Native Rangeland 6.0-m Seasonlong	Native Rangeland 5.5-m Seasonlong	Native Rangeland Deferred Grazing	Native Rangeland 4.5-m Seasonlong
Production Period	Fall Lactation	Fall Lactation	Fall Lactation	Fall Lactation	Early Fall Lactation
Days	30	30	30	30	15
Herbage Wt. lb/ac	797	891	1423	1649	973
Forage Wt. lb/ac	199	223	356	412	243
Crude Protein %	4.8				
Crude Protein lb/ac	9.55				
Acres/Month ac	4.60	4.04	2.53	2.22	3.26
Acres/Period ac	4.60	4.04	2.53	2.18	1.63
Cow Gain/Day lb		-1.74	-0.82	-0.74	-0.52
Cow Gain/Acre lb		-12.90	-9.77	-9.96	-4.75
Cow Gain/Period lb		-52.20	-24.60	-22.20	-7.74
Calf Gain/Day lb	1.80	0.59	0.92	0.77	1.35
Calf Gain/Acre lb	11.83	4.38	10.90	10.36	6.71
Calf Gain/Period lb	54.00	17.73	27.60	23.10	20.33

Table 5 (cont). Vegetation and livestock production values on pasture forage types during the fall lactation period.

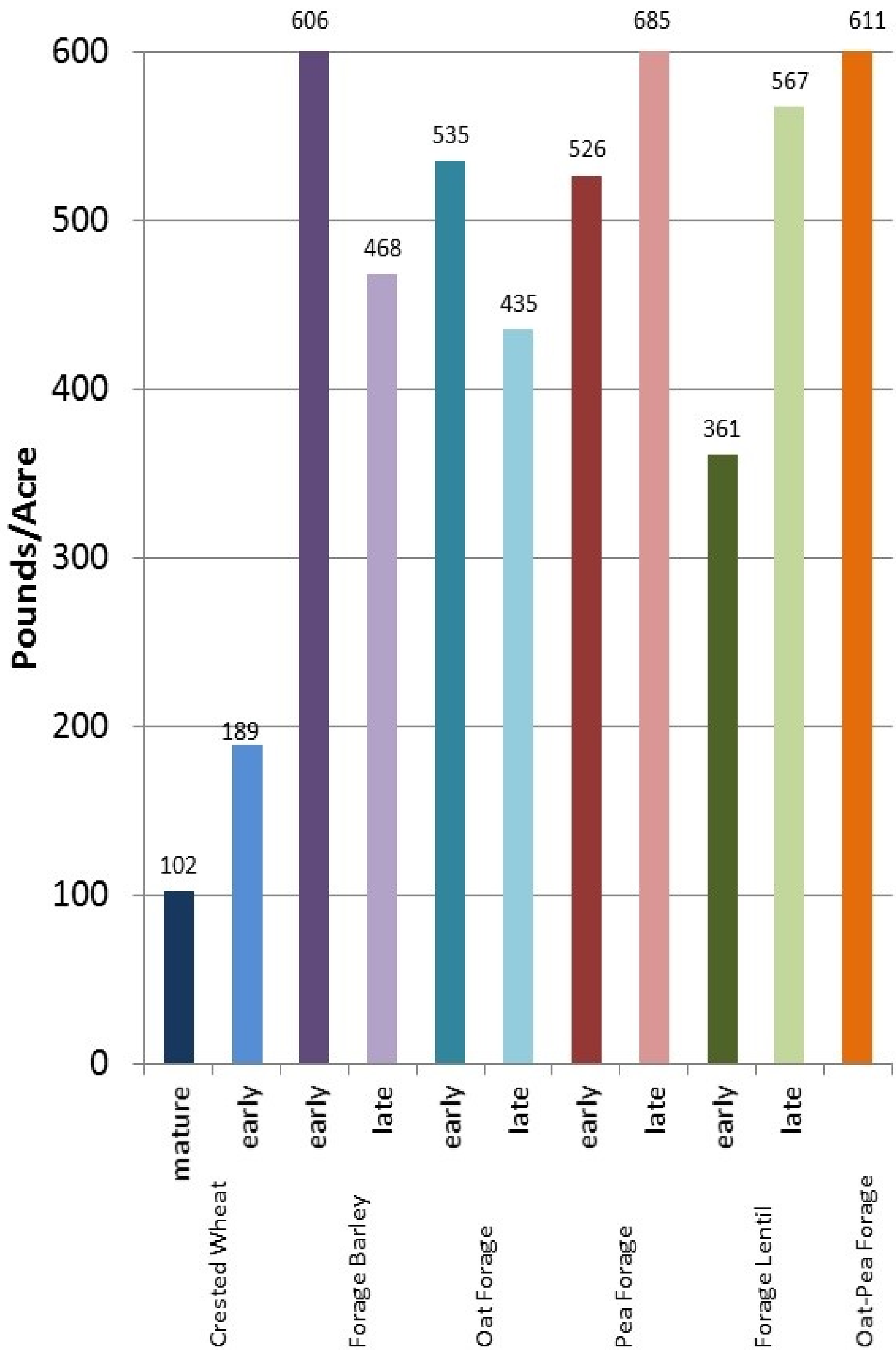
	Altai Wildrye	Cropland Aftermath	Spring Seeded Winter Cereal
Production Period	Fall Lactation	Fall Lactation	Fall Lactation
Days	30	30	30
Herbage Wt. lb/ac	2590	270	
Forage Wt. lb/ac	648	135	1908
Crude Protein %			
Crude Protein lb/ac			
Acres/Month ac	1.39	6.63	0.47
Acres/Period ac	1.39	6.63	0.47
Cow Gain/Day lb	0.55	-1.61	1.05
Cow Gain/Acre lb	11.87	-7.27	67.02
Cow Gain/Period lb	16.50	-48.17	31.50
Calf Gain/Day lb	1.73	0.42	2.00
Calf Gain/Acre lb	37.96	1.90	127.66
Calf Gain/Period lb	52.77	12.57	60.00

Table 6. Vegetation production values on harvested forage types during range cow production periods.

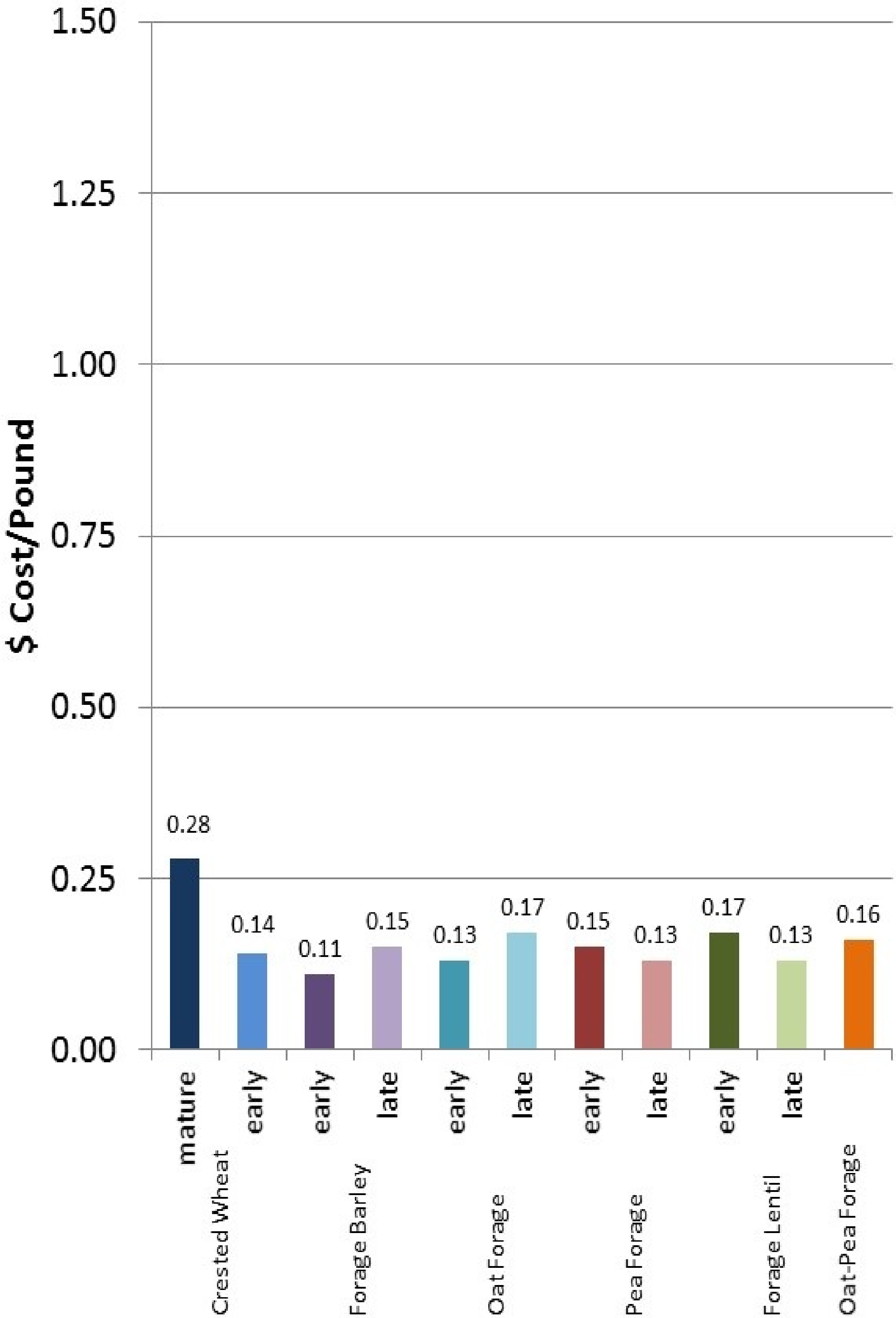
		Crested Wheatgrass mature	Crested Wheatgrass early	Forage Barley early	Forage Barley late	Oat Forage early	Oat Forage late
Herbage Wt.	lb/ac						
Forage Wt.	lb/ac	1600	1300	4733	5133	4667	5667
Crude Protein	%	6.4	14.5	13.0	9.2	11.5	7.8
Crude Protein	lb/ac	102	189	606	468	535	435
Land Area/Period							
Dry Gestation	ac	0.47	0.26	0.08	0.10	0.09	0.11
Third Trimester	ac	1.35	0.89	0.27	0.36	0.31	0.38
Early Lactation	ac	0.76	0.65	0.20	0.24	0.23	0.21
Spring Lactation	ac	0.58	0.41	0.13	0.16	0.14	0.16
Summer Lactation	ac	2.57	1.82	0.56	0.73	0.64	0.73
Fall Lactation	ac	0.56	0.40	0.12	0.16	0.14	0.16

Table 6 (cont). Vegetation production values on harvested forage types during range cow production periods.

		Pea Forage early	Pea Forage late	Forage Lentil early	Forage Lentil late	Oat-Pea Forage
Herbage Wt.	lb/ac					
Forage Wt.	lb/ac	2800	4650	1667	3867	5143
Crude Protein	%	18.9	14.4	21.8	14.7	12.5
Crude Protein	lb/ac	526	685	361	567	611
Land Area/Period						
Dry Gestation	ac	0.09	0.07	0.13	0.09	0.07
Third Trimester	ac	0.32	0.25	0.46	0.30	0.26
Early Lactation	ac	0.23	0.18	0.34	0.22	0.19
Spring Lactation	ac	0.15	0.12	0.21	0.14	0.12
Summer Lactation	ac	0.65	0.51	0.95	0.60	0.53
Fall Lactation	ac	0.14	0.11	0.21	0.13	0.12



Crude Protein Weight Captured per Acre on Harvested Forages During Range Cow Production Periods



Crude Protein Costs per pound on Harvested Forages During Range Cow Production Periods

Table 7. Estimated calf weight performance on harvested forage types during range cow production periods.

Production Periods	Days	Calf Gain per Day lb	Calf Gain per Period lb
Dry Gestation	32	0.78	24.92
Third Trimester	90	0.78	70.08
Early Lactation	45	1.90	85.50
Spring Lactation	31	2.00	62.00
Summer Lactation	137	2.00	274.00
Fall Lactation	30	2.00	60.00

Table 8. Land rent values for western North Dakota.

		Cropland*	Hayland*	Grazingland*	Cropland Aftermath
Mean rent	$/ac	22.07	14.22	8.76	2.00

*Data from North Dakota Agricultural Statistics Service

Table 9. Custom farm work rates in North Dakota.

		Annual Cereal Hay	Annual Legume Hay	Cereal Legume Hay	Perennial Grass Hay
Min till drill	$/ac	9.32	9.32	9.32	
Swath/Condition	$/ac	6.76	6.76	6.76	
Swathing	$/ac				5.31
Custom Work	$/ac	16.08	16.08	16.08	5.31
Baling/1000 lbs	$	5.36	5.36	5.36	5.36

Data from North Dakota Agricultural Statistics Service (Beard 1998)

Table 10. Seed costs per acre.

		Barley	Oat	Pea	Lentil	Oat-Pea
Seed Cost	$/ac	4.69	6.00	23.80	12.60	29.80

Data from NDSU Extension Service (Swenson and Haugen 1999)

Table 11. Intake dry matter and crude protein requirements for range cows with average milk production during the livestock production periods.

Production Period		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation
Days		32	90	45	31	137	30
1000 lb Cows							
Dry Matter	lb/d	21	21	24	24	24	24
Crude Protein	lb/d	1.30	1.64	2.52	2.30	2.30	2.30
1200 lb Cows							
Dry Matter	lb/d	24	24	27	27	27	27
Crude Protein	lb/d	1.49	1.87	2.73	2.51	2.51	2.51
1400 lb Cows							
Dry Matter	lb/d	27	27	30	30	30	30
Crude Protein	lb/d	1.67	2.13	2.94	2.70	2.70	2.70

Data from NRC 1996

Table 12. Daily dry matter allocation for cows grazing pasture forage.

		1000 lb cow	1200 lb cow	1400 lb cow
Dry Matter	lb/d	26	30	33

Data from Manske 2003c

Table 13. Range cow production periods for calf birth in mid March.

Production Periods	Days	Months of Occurrence
Dry Gestation	32	mid November to mid December
Third Trimester	90	mid December to mid March
Mean Calf Birth		mid March
Early Lactation	45	mid March to late April
Spring Lactation	31	early May to late May
Summer Lactation	137	early June to mid October
Fall Lactation	30	mid October to mid November
Mean Calf Weaning		mid November