NUTRITIONAL FACTORS AFFECTING REPRODUCTION AND PRACTICAL NUTRITION FOR BEEF CATTLE RANCHERS

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Introduction

Numerous factors will influence the reproductive efficiency of a commercial cow herd, but nutrition is one of the most important. Reproductive efficiency is more than just the percent of cows pregnant. It includes:

1. Percent cows and heifers bred early in the breeding season
2. Percent pregnancy
3. Percent cows weaning a calf
4. Percent beef females calving unassisted

Many factors influence each of these four factors, but nutrition will have a major effect on each of these items.

Economic Considerations

In analyzing the factors influencing the profitability of a cow-calf operation, feed cost is one of the major items influencing profitability. Obviously, as we focus on low cost production systems, analyzing feed costs must be a key consideration. A recent eight-year summary of the Iowa State University Beef Cow Business Record System compared the most profitable herds to the least profitable. The higher-profit producers averaged $301.60 total cost per cow. The low-profit producers averaged $423.00 per cow. Of this $121.40 difference, $50.00 was due to variations in feed costs. Of particular interest is the fact that even though the more profitable cow producers invested $50 less in feed and pasture costs, their herds produced an average of 98 pounds more calf per cow and had a 2.8% higher calf crop.

In attempting to reduce or keep costs of production to a minimum, it's extremely important that a producer evaluate the nutritional needs of the cow herd and how they relate to the forage resources available. The key in any cattle operation anywhere on the North American continent is effectively matching cow requirements to the available forage resources and then understanding how to properly formulate supplements to cover forage deficiencies.

1. <u>Stage of Production</u>

The first consideration in building a nutrition program is understanding the nutritional requirements of the cow. These requirements vary depending on whether the cow is lactating or dry, the size of the cow, the level of milk production, and the stage of production of the cow.

Table 1 illustrates a cow herd nutrition calendar that starts with calving and ends with the production of the next calf 365 days later. Although this nutritional calendar appears to be based on an individual cow, it fits an operation for the whole cow herd. Period 1 begins on the date when the first calf is born. To ensure that a large percentage of the cows are in the same period and, therefore, can be fed similarly, a short breeding season and subsequent calving season must be utilized.

Table 1. The 365-Day Beef Cow Year by Periods

Period 1	Period 2	Period 3	Period 4
80 days (postcalving)	125 days (pregnant and lactating)	110 days (mid-gestation)	50 days (pre-calving)

Period 1:

To maintain a yearly calving interval, the cow has approximately 80 days from the time of parturition until rebreeding. In the case where it is desirable to move late calving cows to an earlier calving data, the cow may have less that 50 days. Because mature cows typically take from 40 to 80 days to recycle and first calf heifers take from 60 to 100 days, proper nutrition during this period is important. Thus, Period 1 becomes the most critical period, because the cow is maintaining a peak level of lactation, and the onset of cyclicity and rebreeding must occur. Nutrition during this period will have a major influence on conception rates.

Period 2:

Once the cow is pregnant, the major nutritional needs are to maintain lactation. Also, in most production systems, it's advantageous that the cow gain weight during this period, putting on adequate "flesh" for harsh environmental conditions that may await. This is particularly true for spring calving cows in northern climates.

Period 3:

This period has the lowest nutritional requirements. In some environments, this is an ideal time to utilize crop residues, lower quality feeds, or the poorest roughage that is available. However, it's important that the cow not lose excessive weight during this period unless she enters it in fairly good "body flesh." If the cow enters in moderate to slightly below average condition, she should maintain weight and possibly even gain some weight.

Period 4:

This is the period often overlooked in many cattle operations. It should be kept in mind that during this short period (approximately 50 days), approximately 65 to 80 percent of the fetal growth will occur. In cases where typical birth weights are 80 to 85 pounds, this means that from 50 to 60 pounds of fetal growth may occur during this time. Research has shown clearly that improper nutrition during this period will influence calf birth weight, calf vigor, and calf survival. There is no advantage to reducing the cow's plane of nutrition to reduce calf size as a means of alleviating calving difficulty. Poor nutrition during this period will cause a longer postpartum interval, reduce level of milk production, and reduce calf weaning weights.

Table 2. NRC* Requirement for a 1,100 Lb. Beef Cow with Average (15 Lbs/day) Milk Production

	Period			
Nutrient	1	2	3	4
TDN (lbs/day)	13.3	11.5	9.5	11.2
NE, Mcal/day	13.5	12.2	9.2	10.3
Protein (lbs/day)	2.3	1.9	1.4	1.6
Calcium (grams/day)	33	27	17	25
Phosphorus (grams/day)	25	22	17	20
Vitamin A (I.U./day)	39,000	36,000	25,000	27,000

*1984 NRC Requirements for Beef Cattle

2. Flesh or Condition of the Cow

In the past five years, a new term—body condition—has entered the vocabulary of many cattlemen, nutritionists, and veterinarians to describe the nutritional status of cows. The concept is really not new, because for years, operators of well managed cow herds have based their feeding program on the idea "that the eye of the master influences the size of the feed bucket." However, research in the last 10 years has clearly quantified the influence of body condition at calving time and breeding time on reproduction function. Table 3 indicates the impact of body condition at calving time on the onset of cyclicity 60 days postpartum.

Besides the impact on cyclicity, research also has shown that cows that are thin at calving time will have weaker and slower growing calves and will produce less milk.

Table 3. Relationship of Body Condition and % Cows Cycling 60 Days Postpartum

Condition at Calving	Weight Change Pre-Calving	Weight Change Post-Calving	% Cycling 60 Days Post-Calving
Good	Lost	Gained	90%+
Good	Lost	Lost	90%+
Moderate	Gained	Lost	74%
Moderate	Lost	Lost	48%
Thin	Lost	Gained	46%
Thin	Lost	Lost	25%

*Source Whitman, 1975.

Body condition scores are numbers used to suggest the relative fatness of the beef cow. The most commonly used system in the United States ranges from 1 to 9, with a score of 1 representing very thin body condition and 9, extreme fatness. A cow with a body condition score of a 5 or 6 should look in average flesh and probably represent the target for which many cattlemen strive. The following list describes the 9-point body condition scoring system.

1) Bone structure of shoulder, ribs, back, hooks, and pins sharp to touch and easily visible. Little evidence of fat deposits or muscling.

2) Little evidence of fat deposition but some muscling in hindquarters. The spinous processes feel sharp to touch and are easily seen with space between them.

3) Beginning of fat cover over the loin, back, and foreribs. Backbone still highly visible. Processes of the spine can be identified individually by touch and may still be visible. Spaces between the processes are less pronounced.

4) Foreribs not noticeable; 12th and 13th ribs still noticeable to the eye particularly in cattle with a big spring of rib and ribs wide apart. The transverse spinous processed can be identified only by palpation (with slight pressure) to feel rounded rather than sharp. Full but straightness of muscling in the hindquarters.

5) 12th and 13th ribs not visible to the eye unless animal has been shrunk. The transverse spinous processes can only be felt with firm pressure to feel rounded—not noticeable to the eye. Spaces between the processes not visible and only distinguishable with firm pressure. Areas on each side of the tail head are fairly well filled but not mounded.

6) Ribs fully covered, not noticeable to the eye. Hindquarters plump and full. Noticeable sponginess to covering of foreribs and on each side of the tail head. Firm pressure now required to feel transverse processes.

7) Ends of the spinous processes can only be felt with very firm pressure. Spaces between processes can barely be distinguished at all. Abundant fat cover on either side of tail head with some patchiness evident.

8) Animal taking on a smooth, blocky appearance; bone structure disappearing from sight. Fat cover thick and spongy with patchiness likely.

9) Bone structure not seen or easily felt. Tail head buried in fat. Animal's mobility may actually be impaired by excess amount of fat.

Basically, body condition allows us to sort cattle or plan a nutrition program. The initial phase of sorting can often be done by age, because many cattlemen keep two-year old cows separate from mature cows so they can feed the younger females at a higher plane of nutrition. Occasionally, mature cows that are thin will be placed with the two-year olds.

Body condition also can be used to formulate nutritional diets. For a cow to change by one body condition score, she'll have to gain or lose 50 to 80 lbs and on occasion as much as 100 lbs. Thus, if you've got cows that are body condition score 4 at 60 to 80 days prior to the start of calving, and you want to get them to score 5, you've got to strive for an additional 60 to 80 lbs. of weight gain above normal gains. This means that the cows need to gain 1.5 to 2.0 lbs/day to increase their body condition by one score and account for fetal growth.

How much energy (feed) is required to make a one unit change depends on the starting body condition. Thin cows require considerably less net energy (Mcal/day) than "fleshy" cows.

Table 4. Net Energy Requirement of Mature Beef Cows as Influenced by Weight and Level of Milk Production

Energy Requirements	Cow Wt. lb.								
	1000	1050	1100	1150	1200	1250	1300	1350	1400
NE_m, Mcal/d[a]	7.57	7.86	8.13	8.41	8.68	8.95	9.22	9.48	9.75
NE_c, Mcal/d for fetal growth[b]	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
NE_l, Mcal/d (average milk)[c]	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40
NE_l, Mcal/d (superior milk)[c]	6.80	6.80	6.80	6.80	6.80	6.80	6.80	6.80	6.80

[a]NE_m is calculated to be .077 Mcal/kg$W^{.75}$, or .072 + allowance for activity.
[b]Energy required for the conceptus (products of conception) during the last trimester of gestation.
[c]Energy required to support lactation. Average milk is 10 lb of milk production/day; superior milk is 20 lb/day. Calculated as lb of milk x .34 Mcal/lb. This is added to NE_m during lactation.

Calculating the amount of energy that should be provided a beef cow to meet gain objectives must consider the cow's weight and body condition status. The "eye of the master" is still an important factor in feeding the cow herd. Weight and body condition are important criteria to monitor in formulating cow diets. The following illustrates how this can be done. (Reference Guide Lemenger, Purdue Univ., 1990).

Assumption

A mature cow now weighs 1000 lbs., but needs to weigh 1150 lbs. at calving.

- Time to calving = 100 days
- Body condition score = 4 (thin)
- Desired body score = 6 (moderate)
- Weight difference between two scores = 150 pounds

Procedure

1. Determine the average weight of the cow for the 100-day period. Start with the 1,000-pound cow in body condition 2. Add 150 pounds to improve a full condition score to 6, or 1,150 pounds. The average is (1,000 + 1,150 divided by 2) 1,075 pounds.

2. Calculate the average daily gain needed to change a full condition score in 100 days (150 pounds divided by 100 days=1.5 lbs./day).

3. Determine the net energy for maintenance requirement for a 1,075 pound cow from Table 4. This is the simple average between the 1,050 and the 1,100 pound columns (7.86 + 8.13 divided by 2=8.00 Mcal/day).

4. Locate (Table 4) the net energy requirement for fetal growth (2.15 Mcal/day).

5. Add them up. The net energy requirement of 8.00 from Step 3 and the fetal growth requirement of 2.15 from Step 4 equals 10.15 Mcal/day.

6. Determine the average net energy requirement per pound of gain from Table 5 for a cow going from a condition score of 4 to a condition score of 6 and average these two numbers (1.73 + 2.87 divided by 2=2.30 Mcal/day).

7. Next, calculate the net energy requirement for 1.5 lbs./day. The net energy for 1.5 lbs. of gain is 1.5 lbs./day x 2.30 Mcal/lb.=3.45 Mcal/day. This factors in the length of time needed to achieve the desired condition score (100 days).

8. Calculate the net energy for maintenance (NEm) and net energy for gain (NEg) values of the ration. These numbers are calculated by multiplying the NEm and NEg values (Mcal/lb.) of each feed in the ration (using NRC, 1984 feed tables) times the corresponding amount (percent) of each feed in the ration on a dry matter basis, sum the products and divide the resulting NEm and NEg values by 100.

9. Using the calculated numbers from steps 5 and 7, calculate the amount of ration needed per day to obtain the desired end point. Divide the net energy for maintenance requirement (10.15 Mcal/day) by the NEm value (Mcal/lb.) of the ration. This will give the amount of ration needed to maintain cow weight. Next, divide the net energy for gain requirement (3.45 Mcal/day) by the NEg value (Mcal/lb.) of the ration. This is the amount of ration needed to produce 1.5 lb. of gain. The sum of the amounts needed for maintenance and gain equals the amount of ration needed by the cow to reach a body condition score of 6 by calving. A word of caution is in order.

Energy Needed	Mcal/day
Maintenance	8.00
Fetal growth	2.15
For weight gain	3.45
Total:	13.60

Table 5. Energy Required to Change Body Condition

Body Condition Score[a]	Cow wt. lb. 1000	1050	1100	1150	1200	1250	1300	1350	1400
	NE required for 1 lb of weight change, Mcal/lb								
1-3 (very thin)	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
4 (thin)	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73
5 (moderate)	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
6-7 ("fleshy")	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87
8-9 (very fat)	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44

[a]Approximately 75 lb difference between condition scores.

3. Age of Cattle

A good management practice that is used by many cattle producers is to sort cattle by age. The nutritional requirements are different for young heifers being developed than for mature cows. When animals are in a growth stage, it's important to have adequate energy and protein present in the ration to maintain growth. In contrast, with mature cows, particularly those that enter the fall in "good" condition, some weight loss can occur during the winter with no adverse effect on productivity.

One of the keys to having a sound reproductive program with cows is the nutritional management of the replacement heifers. These heifers need to achieve approximately 65 percent of their mature weight by the time they are bred as yearlings.

4. Cow Size and Milk Production

To develop a more productive cow, many cow/calf producers have emphasized growth and milk production in their selection process.

This has tended to increase cow size and level of milk production. Table 6 shows that a 5-pound increase in milk production per cow per day increased the TDN (net energy) requirements by 10 percent and the crude protein requirement by 13-15 percent.

Table 6. Relationship between Cow Size and Milk Production

Cow Size	Milking Level	Lb/Milk/ Cow/Day	Lb TDN Needed*	NE_m, Mcal/ Day*	Lb Crude Protein*
1000	Average	10	11.5	11.0	2.0
	Above Average	15	12.7	12.7	2.2
	Superior	20	13.8	14.4	2.5
1100	Average	10	12.1	11.5	2.0
	Above Average	15	13.3	13.2	2.3
	Superior	20	14.5	14.9	2.6
1200	Average	10	14.0	12.1	2.4
	Above Average	15	12.8	13.8	2.1
	Superior	20	15.2	15.5	2.7

*1984 NRC Requirements

Changes in cow size do not have the same impact on energy requirements that significant changes in milk production do. Each change of 100 lbs. in cow size changes the maintenance net energy requirements by 6-8%.

A common question asked by today's beef producer is: "Can we maintain reproductive efficiency in higher producing cows?" Actually, the question is: "Will a commercial cattle producer adjust his management program and nutritional philosophies to accommodate the added nutrient demands of a higher producing cow?" Ample research indicates that normal reproductive performance can be maintained in more productive cows if the additional nutrient needs are met. The real dilemma facing the commercial cow/calf producer is that the nutritional needs will be increased and, thus, some change in managerial philosophy must occur to accommodate the more productive cow. In making the decision to have a more productive cow, the producer needs to consider the resources available. If there is an ample supply of high quality feed, a heavier, larger milking cow can often be maintained. If the feed supply is limited or if environmental conditions such as drought, which reduces reproductive rates, frequently occur, than maintaining a slightly smaller, somewhat lower producing cow may be the best choice.

5. Effect of Environmental Stress

In monitoring the nutritional needs of cattle, keeping an eye on the weather is important. This is true not only during the critical winter months when severe cold is a problem, but also when wet, damp spring weather affects the nutritional requirements of cattle.

For cows with a winter hair coat, the critical winter temperature is around 30°F (Table 7). When the temperature drops below the critical level (this is not the actual temperature but the wind chill index), there is an increase in the energy requirement. For each 1°F drop in critical temperature, there is approximately a 1 percent increase in the TDN or net energy required.

Table 7. Increased Maintenance Energy Costs for Cattle per Degree (F) Cold

Insulation	Cow or Heifer Weight (lb)				
(C/Kcal/m²/da)	440	660	880	1100	1320
.010	2.3	2.1	2.0	2.0	1.9
.015	1.5	1.4	1.4	1.3	1.3
.020	1.2	1.1	1.1	1.0	1.0
.025	.9	.9	.8	.8	.8
.030	.7	.7	.7	.7	.6

To determine magnitude of cold, critical temperatures is used as a starting point. Estimates of critical temperature for beef cows are shown in Table 8.

Table 8. Estimated Critical Temperature — Beef Cattle*

Coat Description	Critical Temperature	Expected Insulation (C/Kcal/m²/da)
Summer coat or wet	15C (59F)	.010
Fall coat	7C (45F)	.015
Winter coat	0C (32F)	.020
Heavy winter coat	-7C (18F)	.030

*Source Ames, 1973.

Table 9 illustrates the increase in TDN and the amount of hay or grain it would take daily to maintain weight on the cows.

Table 9. Effect of Temperature on Energy Needs

Effective Temperature	Amount of % Increase TDN	Amount of Extra Hay Needed	Extra Grain Needed
50°	0	0	0
30°F	0	0	0
10°F	20%	3 1/2-4 Lbs/Cow	2-2 1/2 Lbs/Cow
-10°	40%	7-8 Lbs/Cow	4-5 Lbs/Cow

Another important item that many cow/calf producers often overlook is the effect of weather in the spring on the nutrient requirements of cows. Cows that have lost weight and are in thin condition are very susceptible to the environmental effects of spring weather. When cattle, even with a winter hair coat, are wet, the critical temperature increases to around 50°F. Thus, during wet spring weather when the temperature is around 30-35°, weight loss can occur. In most cases, these cows are immediately pre- or postcalving and weight loss at this time can have a very detrimental effect not only on milk production and calf performance, but also on how soon the cow will cycle and rebreed.

6. Specific Area Difficiencies

Items that any practitioner or nutritionist needs to consider in formulating cow diets are specific area difficiencies.

Considerable variation can occur in the quality and composition of forage in a particular region. It is virtually impossible to formulate diets without having some appreciation of the forage protein, energy, and mineral content and how this changes during the season. Unfortunately, it is impossible to develop tables that can be used nationwide and, thus, it is imperative that individuals develop nutritional guidelines for their specific areas.

Nutritional Development of Replacement Heifers

The replacement heifer is a mixed blessing for most cow/calf operators. On the one hand, she represents the future profitability and genetic improvement of the cow herd. Thus, her selection and development is of paramount importance to the continued success of the operation.

On the other hand, the replacement heifer is an inconvenience, at best. Her smaller size and higher nutritional requirements dictate that she be raised and managed separately from the rest of the herd. Yet, the fact that she is essentially non-productive for the first two years of life makes her easy prey for mismanagement. However, the growth and development of the replacement female from birth until she produces her first calf is of critical importance, in order for her to become a highly productive part of the cow herd.

The development of replacement heifers can be divided into three phases: 1) preweaning; 2) weaning to breeding; and 3) breeding to calving.

1. *Preweaning*

During this phase, we largely depend on the dam to nurture and care for the replacement heifer until weaning. However, the influence of a few management practices should be mentioned. Producers are encouraged to individually identify (ear tag, number brand, etc.) both cows and calves, so that selection of replacement heifers can be based upon objective records of birth dates and weaning weights from consistently early calving, high producing cows.

The replacement heifer should weigh at least 450-600 lbs. at weaning, depending upon breed, frame, and feed supply. It is important that this weight be the result of true skeletal and muscle growth without a substantial amount of fat. Research at several locations has shown that feeding a high energy creep feed to suckling heifers of British breeding will hinder their subsequent milking ability because of fat deposition in the developing udder. However, a recent summary of large framed heifers of European breeding showed no effect of creep feeding on subsequent maternal performance. Thus, the creep feeding of replacement heifers, when economically feasible, should depend on the breeding and growthiness of the calves, with no creep or lower energy, bulky creep feeds being used on smaller framed heifers.

2. *Weaning to Breeding*

Once the replacement heifer is selected at weaning, making sure that she grows and develops properly prior to breeding has a profound impact on her subsequent productivity. Replacement heifers need to weigh about 65-70% of their mature weight in order to consistently breed as yearlings. Thus, a good nutrition program is essential. Generally, heifers should gain 1-1 1/2 lbs. per day from weaning to breeding, depending upon their weaning weight and the length of the feeding period prior to breeding. Usually, this means that the average British-bred heifer will need to gain about 250 lbs. in order to weigh the 650-700 lbs. necessary to begin cycling. With the larger framed European breeds and crosses, a target breeding weight of 700-800 lbs. is usually necessary.

Puberty in heifers is a function of breed, age, and weight. Recent research has illustrated that the degree of development from weaning to breeding influences not only how soon heifers cycle (reach puberty) as yearlings, but also their subsequent productivity and rebreeding rate after they calve as two-year olds. Research at K-State and at Purdue, as shown in Table 10, indicates the impact of inadequate growth and development during this phase.

Table 10. Effect of First Winter Nutrition on Subsequent Performance of Heifers*

	Lb of Grain Per Head Fed Daily in Addition to Low-Quality Fescue Hay Fed ad libitum		
Item	0.0	3.0	6.0
Number of heifers	112	113	112
Initial fall weight, lb	496	502	493
Daily gain — winter, lb	0.07	0.50	0.80
Breeding weight, lb	506	577	613
Percent conceiving as yearlings	69.2	73.9	83.5
Subsequent production:			
Percent rebreeding after first calf	67.3	75.4	87.1
Weaning weight — first calf, lb	405	433	443

*Lemenger, Purdue University, 3 year trial summary, 1980.

It should be emphasized that replacement heifers need to be fed separately from the rest of the herd. Because of their size and age, as well as higher nutritional demands, they simply cannot compete with the rest of the cow herd, nor can they be expected to efficiently utilize poorer quality forages and still breed as yearlings.

Cow/calf operators are encouraged to have their replacement heifers cycling early so that they can be bred 3-4 weeks before the rest of the cow herd. The stress of calving is greater on heifers than older cows, and heifers are more likely to have calving difficulty. Thus, breeding replacement heifers essentially one heat cycle earlier than the mature cow allows the producer more time to watch the heifers at calving time and gives the heifer the extra time she needs to start recycling and breed back "in sync" with the rest of the herd. In addition, the weaning weights of calves from replacement heifers that are bred 3-4 weeks early will usually be increased 30-45 lbs. because the calves will be older.

If it is impractical for a cow/calf producer to breed his replacement heifers prior to the rest of the cow herd, he should then stress a very short breeding season for them. The place to start emphasizing reproductive efficiency in a cow herd is with the replacement heifers. Utilizing a short breeding season (35-45 days) ensures that the producer is keeping fertile replacements that conceive promptly. This will also force the heifers into a short calving season, so that the producer can give them more attention.

3. *Breeding until Calving*

The final step in the profitable management of the replacement heifer is to ensure her adequate growth and development from breeding until she calves as a two-year old at about 85-90% of her mature weight. During this time, the bred heifer should gain about 3/4-1 lb. per day, or about 250-300 lbs. Thus, British bred heifers and crossbred heifers of British breeding should go into the calving season weighing 850-1000 lbs., and the larger framed breeds and crosses should weigh 950-1050 lbs. It is preferable for the heifer to grow continuously throughout this phase. For spring calving herds, summer pasture is usually adequate for the first half of this period. However, it is important to recognize that most of the fetal growth occurs during the last 50-60 days prior to calving. Thus, adequate nutrition, especially energy (fed apart from the mature cows), is essential for proper development of the fetus and to prepare the heifer for calving and lactation. To help monitor the status of the heifer's nutritional development, use body condition as a guide, with a body condition score of 6 as the targeted goal.

Research at several agricultural experiment stations has consistently shown that roughing the heifer along prior to calving results in lighter, weaker calves at birth without any decrease in calving difficulty, greater calf sickness and mortality, lower milk production, slower return to estrus, and poorer overall reproductive performance. Thus, "shorting" the heifer nutritionally prior to calving is an invitation to disaster!

Practical Considerations

1. Forage Intake

The fact that virtually all cow nutrition programs are forage-based means that at some time during the year, cattle will be grazing various types and qualities of forages. The weekly variation that occurs in forage quality and the difficulty in estimating forage intake make precise formulation of cow diets difficult.

The three major factors influencing forage intake are the quantity and quality of available forages and existing environmental conditions. The quantity of available forages is often the first limiting factor. In pastures, crop residue fields, or ranges where abundant available forage exists, animals can selectively graze the most nutritious plant parts that are available. As the quantity, or the quality declines, the amount of intake per grazing bite tends to decline.

In cattle grazing extremely high quality spring and summer forages, the intake may range as high as 2.8 to 3.5% of the body weight on a dry matter basis when the forage quality is highest. As the plants mature, this declines to intakes of approximately 1.5% of the body weight on a dry matter basis for very mature, low quality forages. Characteristically, cattle graze at all hours of the day or night. However, evidence exists that the two most common grazing periods are around sunrise and late afternoon, both of which can be affected by environmental temperature and conditions.

Knowing and understanding when cattle graze can have an impact on when supplements are fed. Because supplements should complement the forage, their value is greatest when they are fed at a time that does not disrupt grazing. Research evidence exists that supplemented cattle may not graze for two to four hours following supplementation. Numerous environmental conditions can impact forage intake. In the northern hemisphere, snow cover often precludes late fall and winter grazing. Up to a point, cold stress will stimulate intake. However, once a certain temperature is reached, actual daily foraging of the cattle will decline. Recent research indicated that as temperatures drop below 0°C, up to a 50% reduction in total daily grazing time occurred.

Table 11 gives a general rule of thumb for expected intakes of cows expressed as a percent body weight on a dry matter basis.

Table 11. Intake of Forages of Various Qualities

Forage Quality	Percent Body Weight Intake
Excellent	2.8 - 3.5%
Average	2. - 2.5%
Crop Residues and slightly below average quality	1.8 - 2.%
Extremely poor quality	1.4 - 1.8%

2. Meeting Protein Needs

The second most expensive nutrient in a cow herd nutrition program is protein. Protein plays a particularly major role during lactation. Likewise, it plays a major role by affecting appetite, which alters the level of forage and, therefore, the level of energy that animals will consume. Research (Bull et al., Idaho) has shown that the amount of protein consumed by the cow during the last 60 days pre-calving was associated with the "weak calf syndrome." Early work linking excess protein levels in the cow diet with increased birth weights has not been supported by subsequent research.

Another important reason to consider protein is that it is often the nutrient most likely to be purchased in a typical cattle operation. Cattlemen need to consider both protein and energy in the initial formulation of cow diets. Some of the common mistakes in feeding protein to beef cows are listed below:

Over-Feeding during Mid-Gestation. A typical 1100 lb cow of average producing ability will need only 1.4 to 1.6 lb. of crude protein during the middle part of gestation. However, in many cases, producers will feed a roughage of fair quality during this period and also feed a protein supplement, which actually is not needed.

Under-Feeding Protein after Calving. When a cow calves, her requirements are considerably higher. For a cow producing 15 lb. of milk, the requirements are 1.9 to 2.3 lbs. of crude protein after calving. But when that cow produces 22 lb. of milk, the level of protein needed is increased to 2.7 lb. Many nutritionists feel that the NRC requirements for the postpartum cow are underestimated. This is supported by the following Kansas study (Table 12).

Misuse of NPN or Urea. Urea is a very cheap source of nitrogen and, in many cases, can be fed successfully to cattle, particularly feedlot steers. Yet in most cow herd nutrition programs, when forage is often limited or of low quality, urea is poorly utilized because of a lack of available energy. When urea is fed to beef cows under these conditions, a negative response to the high-urea protein supplements can occur, causing a weight loss and subsequent reductions in weaning weights and reproductive performance. In order for urea to be successfully utilized, it must be accompanied by adequate energy and fed to cows being maintained in a positive energy balance.

Table 12. Effects of Amount of Dietary Protein on Cow and Calf Performance[b]

Item	100% NRC	150% NRC
Initial weight	792	783
Cow gain, lb/day	0.58	0.87
Initial BCS[a]	4.6	4.4
BCS change	-0.11	+0.1
Calf gain, lb/day	1.28	1.56
Milk production, lb/day	10.9	12.1

[a]BCS=body condition, 1 to 9 scoring system.
[b]Rusche et al., 1992.

3. Vitamin A Considerations

Although many vitamins are known to be important to cattle, the one that is addressed most commonly in cow/calf nutrition is vitamin A. All cattle require a dietary source of vitamin A, because it is needed for proper maintenance and function of epithalial tissues of the body.

Research evidence has indicated that cattle are quite capable of protecting or storing large quantities of vitamin A in the liver during periods of high intake. In plants, vitamin A occurs in a precurser form as carotene, which is also often stored in body fat. Thus, in most systems, liver storage is adequate. When depletion does occur and a serious deficiency develops, symptoms include respiratory infection, reproductive disorders, night blindness, rough hair coat, slow growth, muscular incoordination, and even excessively watery eyes.

The requirements for cows at various stages of production are shown in Table 2. The most common ways of supplying vitamin A in cow/calf operations are as follows:

1. The use of forages known to be high in vitamin A, such as alfalfa and other legumes.

2. Inclusion of vitamin A in mineral mixes and even protein supplements that are either self fed or fed on a daily basis.

3. Injectable vitamin A administered either prior to calving or on occasion twice a year with cows given both fall and spring injections.

4. Meeting Phosphorus Needs

Importance. In formulating cow diets, one of the most important minerals to consider to maintain normal reproductive function is phosphorus. Because we build cow diets around forage utilization, this often means grazing fall and winter forage which is fairly deficient in phosphorus. Phosphorus supplementation is important in most parts of the United States, but it becomes more important in areas of the country where cattle are maintained on grazed forage year around. Thus, in areas of the country such as Arizona, New Mexico, Texas and Oklahoma, phosphorus deficiency is more likely to be observed than in parts of the country where cows are routinely maintained on summer grass and then fed harvested forage during the winter months, both of which often contain adequate phosphorus. The phosphorus supplementation program you use should be influenced by the phosphorus content of the forage being fed and the requirements of the cow.

Requirements. First let's look at the phosphorus requirements of the cow. An 1,100 pound cow will have the following requirements:

	Stage of Production	Daily Requirements of Phosphorus (grams)
	Mid Stage	17 grams
Pregnant	Late Stage	20 grams
	10 lbs/day	22 grams
Lactating	20 lbs/day	28 grams

To adjust these requirements, the following guidelines should be used:

1. Adjust the phosphorus requirement by 2 grams per 100 pounds of change in cow body weight.
2. Adjust these requirements by .5 grams per pound of milk change.

Forage phosphorus content. The next step in formulating phosphorus requirements is understanding the phosphorus content of the forage during the year. As with most nutrients, the phosphorus content in forages is highest during the lush growing season and lowest during the winter.

Average Phosphorus Content*

Time of Year	Bluestem	Short	Native Range Corn Stalks
Early Spring	.34%	.28%	---
Summer	.15%	.18%	---
Winter	.07%	.08%	.12%

*KSU Range Data.
**Denham, Colo. Livestock Forage Analysis Handbook.

Calculate how much phosphorus the cows are consuming. The next step is to calculate how much phosphorus the cows are consuming, based on actual intake. Based on various intakes and phosphorus content, the following table illustrates the quantity of phosphorus the cow would be consuming. As can be noted, the period when cows are most likely deficient is when they are grazing early and late winter range forages or crop residue fields. **Given the opportunity, cattle selectively graze which results in forage consumed that is generally higher in phosphorus than what is present in clipped samples.**

Projected Phosphorus Intake as Influenced by Time of Year and Forage Phosphorus Content (Assumes an 1100 lb Cow)

Time of Year	Intake (% of Body Wt.)	% Phos. in Grass	Daily Phos. Intake (grams)
Spring	3.0%	.28%	41.9
	2.7%	.28%	37.8
	2.4	.28%	33.5%
Fall	2.4%	.12%	14.4
	2.1%	.12%	12.6
	1.8%	.12%	10.8
Winter	2.1%	.08%	8.4
	1.8%	.08%	7.2
	1.5%	.08%	6.0

How much phosphorus is being consumed by the cow from the mineral mix? The next step is to estimate how much phosphorus is being consumed from the mineral mix. A typical mineral mix used during the winter months will have approximately 10% phosphorus. Unfortunately, we have been discussing requirements in terms of grams, but cattlemen think in terms of pounds. Remember, there are 454 grams in a pound, thus taking one pound, or 454 grams, times 10% means that each pound of mineral mix contains 45.4 grams. Thus, if the daily mineral intake was:

.1 lb—this supplies 4.54 grams/day (45.4 X .1 lb)
.2 lb—supplies 9.08 grams/day (45.4 X .2 lb)

What's the cheapest way to supply phosphorus and still be effective? The final step is how can I supply phosphorus in the cheapest manner. Just as we do with energy and protein, the calculation involves figuring out the cheapest way of supplying a unit (gram or pound) of phosphorus. The calculation to get at that is as follows:

1. Determine the percent of phosphorus present and the price per ton for mineral.

2. Divide the price per ton by 2,000 lbs which gives you the cost per pound of the mineral mix.

3. The next step is to determine the quantity of phosphorus in that pound, which can be done by taking percent phosphorus in the supplement times 454 grams (a pound) which gives you the level (grams) of phosphorus present in each pound of mineral mix.

4. Then simply divide that into the cost per pound to come up with the cents or fraction of cents to supply a gram or pound of mineral mix. Initially, this is going to seem like a frivolous calculation because you are dealing in fractions of cents or a few cents. But keep in mind that when you take this over a 365 day cow year, and take that times 100 or 200 or 300 cows or more, it can add up to a lot of dollars.

Examples — Based on varying mineral mix prices the following is the cost/lb of actual phosphorus.

Mineral Mix	Cost/Ton	Phos Content	Cost/Lb Phos
A	$400	12%	$1.67
B	$300	8%	$1.87
C	$250	8%	$1.56

5. <u>Meeting trace mineral needs.</u>

The trace elements most likely to influence reproduction in cattle are six elements: copper, cobalt, iodine, selenium, zinc and manganese—deficiencies of which can occur in the grazing ruminant and affect reproductive performance or related important economic production parameters.

Other elements such as iron and molybdenum can be important considerations, but seldom from a deficiency standpoint. In both cases, excesses can have an impact on the animal most notably by their negative impact on copper utilization.

COPPER

General importance and effect on reproduction. Copper (Cu) is involved in numerous body physiological functions such as: hemoglobin formation, iron absorption and mobilization and connective tissue metabolism—usually via copper's involvement in enzyme function. In fact, one of the major affects of copper deficiency may well be its effect on enzyme systems reducing productivity via alteration of enzymatic activity in the body.

Specifically, it appears that copper may play a role in two key areas—altered reproductive performance and immunosuppression.

In a number of research studies it's been clearly documented that a copper deficiency can have an effect on fertility. This has been evidenced by a reduction in first service conception rates, altered embryonic survival (in situations of embryo transfer) and a reduction in overall pregnancy rates. The effect on fertility can range from a very limited effect to a very pronounced decrease in first service conception and overall pregnancy rates. It is interesting to note that in a number of studies where copper deficiency has clearly been documented, there often is no impact on fertility or any other reproductive parameter.

In addition to its effect on fertility, research has shown that there will be an alteration in reproductive behavior, or manner in which cows show estrous activity. Specifically, cows may show normal estrus behavior and then in situations where a severe copper deficiency develops, ovulation does not occur and, subsequently, there is a retardation of future estrous cycles. In addition, there is evidence that copper can cause an alteration in semen quality in males.

Exactly how does copper alter reproductive function in animals? Some excellent research data reported by Phillippo et. al., (1987), showed that the effect on reproduction may not relate to a copper deficiency, but rather may relate to the copper deficiency being created by excesses of other trace elements such as molybdenum and sulfur. In their study they showed that the dietary inclusion of molybdenum delayed puberty in yearling beef heifers by 8-12 weeks, reduced conception rates from 68% in cows with no molybdenum included in the diet to 22% when molybdenum was included in the diet. In addition, this research showed that the failure of the cattle to ovulate may have related to molybdenum's interference rather than a copper deficiency. Specifically, the mode of action in which molybdenum might be causing this is not clearly known. In the heifer studies where puberty was delayed, it was shown that the secretion of the hormone LH (luteinizing hormone) was altered as the pulsatile release of LH was not observed and there was a lower basal level of LH secretion. Further, their studies showed that this alterated LH release pattern may have related to ovarian estradiol production. When estradiol was supplemented, normal LH secretion occurred and the animals did not exhibit altered ovarian function.

One of the effects of the copper deficiency that is not well documented but may have the greatest economic consequence on the industry is its impact on immune system function in animals. In incidences of copper deficiency, it appears that the immune system is altered in animals making them more susceptible to a variety of diseases. The incidence of scours has increased in calves born to copper deficient dams. Documentation has shown that abomasal ulcers shortly after birth is related to a copper deficiency in the calves. Other studies have reported respiratory problems in copper deficient calves.

Clinical Symptoms. Copper deficiency clinical symptoms are extremely varied. From a physical appearance standpoint via the enzyme, polyphenyl oxidase which effects the conversion of L. tyrosine to melanin, there often is an alteration in the hair coats of animals. This may show up simply as a lightening of the hair coat in black or red animals, or may show up as reddish tinge in the case of black animals, which will appear behind the shoulder and on the lower quarter. Another feature is graying of the hair in black animals. On occasion, a copper deficiency may appear as graying of the hair around the eyes creating virtually a "ring." In general, "rough" hair coats is a common deficiency symptom.

Other symptoms include a general anemia condition, and abnormal bone and ligament development creating an inability of calves to walk or animals more susceptible to foot and leg injuries. On occasion growth rate of animals can be effected.

As previously discussed, one of the clinical signs can be reduced reproduction function, or an effect on immune function.

Diagnosis. Diagnosis of any trace element often needs to be based on a number of factors. This can include general clinical symptoms as previously described, data from blood or liver analysis, or information from a forage analysis. If any of the possible clinical symptoms appear, one of the early steps should be analysis of forage for copper levels. When this analysis is made, it's important to also analyze for molybdenum, sulfur and, possibly, iron. One of the effective means of confirming a copper deficiency is via liver biopsies which, when performed by a veterinarian with biopsy experience, will cause minimal physical discomfort to the animal or damage to the liver. Serum samples can be used as a general indicator, but diagnosis based on just blood analysis can be misleading. When forage samples contain less than 8-10 ppm copper they start bordering on being deficient. This especially is a problem when molybdenum levels are in excess of 1-3 ppm, or that the copper molybdenum ratio falls below 3:1 or 4:1. In some situations, the author has seen copper molybdenum ratios of 1:5. When liver biopsies are taken, levels below 25-30 ppm dry wt. basis are considered deficient. Serum samples below .6 ppm indicate a potential deficiency may exist.

Treatment. Once a determination has been made, there are a number of ways a copper deficiency can be treated. **It's important to keep in mind that excess copper should not be routinely added to a diet without prior clinical determinations made, because excess dietary copper can be toxic to the animal.**

The most common methods of treating a copper deficiency are as follows:

a. **Mineral mixes.** When a deficiency is diagnosed, increasing copper content of the mineral mix to .2 to .5% can correct a copper deficiency, particularly if it is simply a deficiency associated with low levels of copper in the forage. In cases where high levels of molybdenum or sulfur are causing a problem, it may require in excess of .5 percent copper in the mineral.

b. **Copper boluses.** There are copper boluses on the market that contain copper oxide needles. Research in Kansas has shown that the liver copper content can virtually be doubled by the use of copper boluses.

c. **Copper injections.** The most common way of treating a copper deficiency is either through the mineral mix or through the use of boluses. But, in case of a deficiency needing a rapid correction, one of the fastest and most effective treatments is through the use of copper injections such as copper glycinate or copper EDTA. It should be noted that copper injections will often cause some reaction at the injection site.

Toxicity. When levels of copper in the diet exceed 200-800 milligrams per kilogram of body weight in cattle, or 115 ppm in calves, these are considered to be potentially toxic levels.

MANGANESE

General importance and effect on reproduction. Considerable attention in the livestock industry is focused on trace element deficiencies such as copper, selenium, zinc and other elements. One of the hidden trace elements that may have considerably more influence than we realize is manganese.

Manganese is nutritionally essential to both plants and animals and, unfortunately, is very poorly utilized from the diet by animals with evidence that only 14-18 percent of ingested manganese is actually absorbed.

Like copper, manganese probably exerts its greatest influence on the animal via its effect on enzyme systems. Research evidence suggests that manganese deficiencies can impact conception rates, delay estrus in postpartum females and delay puberty in heifers. In addition, there's excellent evidence that manganese deficiency will cause abortions in animals and deformed calves at birth. There's been evidence manganese deficient calves will "knuckle over" at the fetlock at birth. Other symptoms reported include poor calf growth, loss of hair color in both calves and cows, and an increase in the incidence of cystic ovaries.

The mode of action by which manganese causes this deficiency is not clear other than it appears to be exerting these influences via enzyme systems. There is strong evidence, for example, that the manganese content of ovaries in normal cows was considerable higher than in those with high incidences of cystic ovaries. There's also excellent evidence that manganese, via its effect of enzymes systems, alters the synthesis of gonadal hormones such as estrogen and progesterone in the female. Part of this explanation relates to the role of manganese in altering ovarian luteal metabolism.

Clinical symptoms. As previously described, altered reproductive efficiency, delayed puberty, abnormal calves at birth and hair color alteration are all symptoms associated with a manganese deficiency. There is not clear evidence at this time that manganese has a direct effect on immune system function, as is the case with copper, selenium and zinc.

Diagnosis. One of the most effective diagnosis of a manganese deficiency is simply a determination of the manganese content in the diet or forage being fed. A diet is considered deficient if less than 30-40 ppm manganese is present.

Blood (below .005 ppm) and liver (below 2.5-3.0 ppm) samples can also be useful indicators of a manganese deficiency.

Treatment. One of the most common ways of treating a manganese deficiency is simple inclusion of sources of manganese in a mineral mix. One source of manganese commonly used is manganese oxide.

Toxicity. Unlike a number of the other trace elements, excess levels of manganese in the diet generally is not toxic.

SELENIUM

General importance and effect on reproduction. Selenium, an important trace element in many areas of the United States, can be both deficient and toxic even within the same state. Any discussion of selenium needs to also include vitamin E.

One manner in which a selenium deficiency can affect production in a cowherd is an increase in the incidence of early embryonic death. In addition, another common clinical symptom associated with selenium deficiency is an increase in the incidence of retained placentas with evidence in dairy herds of a selenium deficiency increasing the incidence of retained placenta from a level of 8-10 percent to 50 percent.

Another effect of a selenium deficiency associated with reproductive functions is an increased incidence of cystic ovaries and an increased incidence of weak or silent heat periods. Finally, evidence exists linking selenium deficiency to weak calves at calving time.

The mode of action under which selenium may effect reproductive function is not clearly defined. It appears to function through its affect on the metabolism of hydroperoxide which may alter the synthesis of prostaglandin or its derivatives. This affect could then be associated with its impact on a number of reproductive parameters.

As with copper, there is excellent evidence that a deficiency of selenium will alter the immune system function in animals making them considerable more susceptive to disease problems.

Clinical signs. As previously discussed, early embryonic death, increased incidence of retained placentas, increased incidence of cystic ovaries and silent heats, coupled with weak calves at the time of birth can be associated with selenium deficiencies.

Diagnosis. One of the most effective ways of determining selenium deficiency is a liver analysis. Liver levels of .25 to .5 ppm on wet weight basis is considered to be adequate and levels below .2 ppm considered to be deficient. As a general indicator of potential selenium deficiencies, blood samples (serum) can be utilized with .05 ppm and below considered to be deficient.

Treatment. A number of methods of selenium treatment exist. NRC (National Research Council) suggests a dietary level of .2-.3 ppm selenium.

To treat a deficiency, inclusion of selenium in the mineral mix in one commonly practiced procedure. In addition, selenium/vitamin E injections can be given at three month intervals with very effective responses being achieved in some of the research studies. Finally, selenium boluses are also available for use in areas that are documented as selenium deficient.

Toxicity. Unfortunately, selenium is much like copper in that it can be both toxic and deficient with variability occurring even within a state. Diets containing over 80 ppm are considered to be toxic. Toxic signs include loss of appetite, loss of tail hair, sluffing of hooves and even death.

ZINC

General importance and effect on reproduction. Zinc, as with all of trace elements, is extremely actively involved in enzyme function, most notably metalloenzymes. The role of zinc in reproductive function appears to be more pronounced on the male side than on the female side. Evidence exists in research studies that zinc deficiency in the bull causes impaired fertility, possibly associated with an alteration in the late stage spermatozoa formation. This impairment of male infertility appears to be associated with the role of zinc as an activator of enzymes involved in steroidogenesis process which results in the secretion of testosterone and related hormones. Also, evidence exists that zinc may impact sperm motility through its effect on ATP's role in contraction. In the female, there is some evidence for a decrease in fertility and for some indication for abnormal estrous behavior.

There is also research evidence that zinc may play a greater role in the growth of stocker/feedlot cattle, and excellent evidence to indicate zinc plays a role in immune system function in stocker and feedlot cattle which may transpose to some affect in the cow, though this has been less well documented.

Clinical signs. As previously stated, there is documented evidence for altered reproduction in bulls some evidence of decreased fertility and abnormal estrous behavior in cows.

Diagnosis. The requirements as listed by the National Research Council (NRC) suggests that 30 ppm is the recommended dietary level with a range of 20 to 40 commonly referred to. As with other trace elements, blood can give some indication of a deficiency, however, care needs to be taken in interrupting serum levels. A more accurate determination can be made through either liver biopsies or through forage analysis. Liver tissue samples testing below 25-30 ppm are considered marginal or deficient.

Treatment. The inclusion of zinc in the diet in the form of zinc oxide, zinc carbonate, zinc sulfate or zinc methionine have proved successful as a means of supplying zinc to cattle.

Toxicity. Evidence of zinc toxicity in adult ruminants is relative uncommon. However, there has been evidence that animals receiving above 500 ppm can show toxic effects.

PROBLEMS ASSOCIATED WITH TRACE ELEMENT SUPPLEMENTATION

There are four key problems associated with trace element supplementation that unfortunately preclude as precise a recommendations as is needed in the industry. These are:

1. Trace element requirements in animals are poorly defined and seldom in cow diets are these requirements altered to fit the level of productivity of the cow.

2. There is considerable variability in the level of trace elements found in forages and the factors that influence this variability is poorly documented in most states.

3. There is tremendous variability in the trace element content of mineral mixes sold commercially. In fact, it is often difficult to obtain this information at least through local sales personnel.

4. The mode of action of how trace elements may impact reproductive function and immune system function are extremely poorly defined, an/d additional research is certainly needed.

6. Water requirements.

The water requirements of cattle are influenced by a number of physiological environmental factors. These will include such things as rate and composition of gain, pregnancy, lactation, physical activity, type of ration, salt, dry matter intake, and environmental temperature. Table 13 estimates daily water requirements of cattle as they relate to month and mean temperature.

Table 13. Estimated Daily Water Intake of Cattle

Month	Mean Temp.	Cows		Bulls
		Nursing Calves[1]	Bred Dry Cows & Heifers	
	°F	Gal	Gal	Gal
January	36	11.0	6.0	7.0
February	40	11.5	6.0	8.0
March	50	12.5	6.5	8.6
April	64	15.5	8.0	10.5
May	73	17.0	9.0	12.0
June	78	17.5	10.0	13.0
July	90	16.5	14.5	19.0
August	88	16.5	14.0	18.0
September	78	17.5	10.0	13.0
October	68	16.5	8.5	11.5
November	52	13.0	6.5	9.0
December	38	11.0	6.0	7.5

Source: Paul Q. Guyer, University of Nebraska
[1]Cows nursing calves during first 3 to 4 months after parturition—peak milk production period.

Detecting potential problems in water is often difficult. Unfortunately, unless you know exactly what to analyze for, water analysis tests may not provide the answer. However, in a number of situations, excessive salinity—too high a concentration of dissolved salts, may be one of the more common problems affecting water intake or making water unacceptable to animals. Other factors that may enter into a water evaluation are nitrate contents and alkalinity.