BEEF CATTLE NUTRITION AND FEEDING

- *References: Bowman & Sowell (1998) & Galyean & Duff (1998) in Kellems & Church (19980), NRC (2000. Update), and Jurgens (2002).*

BEEF BREEDING HERD

1. General

A. The one most important consideration? - A high percentage of calf crop, i.e., a live calf from each cow each year!

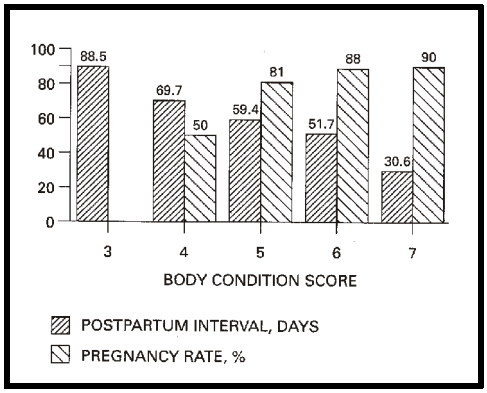
B. Cow-calf operation relies heavily on grazed forages:

1) Much of the requirements for protein & energy can be met with low- to medium-quality forages. Can use native rangelands & introduced pastures.
2) Feed hay when weather conditions limit grazing or forage availability.
3) May need supplemental feeding during late gestation & lactation with limited forage quantity or quality.

C. Biological cycle? - Can be divided into four period:

1) First trimester - Needs nutrients for maintenance & lactation (if the cow has a calf) - Body weight & breed effects on the maintenance needs, and the rate of milk production & fat content affects the nutrient needs in those lactating.
2) Second trimester - Calf is weaned & lactation needs end, thus the time of lowest nutrient needs for the beef cow.
3) Third trimester - Nutrient needs are increasing rapidly because of the fetal growth, thus need to watch body condition carefully.
4) Postpartum interval - Critical period for the cow because lactation needs are high & also the cow's reproductive system is recovering from parturition. Feed intake is 35 to 50% higher vs. non-lactating.

2. Cow Herd



A. Cows gaining just before and during the breeding season will show a shorter period between calving & the first estrus, and tend to have high conception rates. [Effect body conditioning score at calving (Bowman & Sowell, 1998)].

B. The most important period in terms of nutrition? - 30 days before calving until 70 days after calving (. . . until after rebreeding).

C. Usually, either a spring (March through April) or fall (September through October) calving:

1) Can avoid severely cold weather & extreme heat of summer.
2) In general, producers favor the spring calving because of minimum housing needs and use of less harvested feed.

D. Energy and nutrient needs vary depending on the frame size and condition of the cow, stage of production and environmental conditions, but generally cows require the followings - See the table (Jurgens, 2002).

Ration	Pregnant Cows	Lactating Cows
Protein, %	7-9	9.5-12.5
Protein, lb/d	1.1-1.7	1.8-2.9
TDN, %	49-64	55-68
TDN, lb/d	8-13	10.5-16
ME, Mcal/lb	0.8-1.1	0.9-1.3
ME, Mcal/d	14-21	18-28
Ca & P, %	0.2-0.3	0.25-0.5
Ca & P, g/d	15-25	25-40

1) Energy:

a) Considered first in diet formulation - Energy intake can determine the ability of the cow to utilize other nutrients to a large extent.
b) Affected by mature body size (higher maintenance needs for larger cows), physical activity (30 to 50% more free-grazing vs. confined cows), and environmental temperatures.

2) Protein:

a) Microbial protein supplies about 50% of the protein & amino acid needs.
b) Protein deficiency - The most common deficiency in cows grazing mature forages or low-quality hays, or straw.
c) With < 7% CP, not enough ruminal N/ammonia for the microbes, thus resulting in reduced digestion of forages & forage intake.

3) Minerals:

a) Pregnancy and high milk production can increase the needs for Ca & P - If not consuming adequate amounts, various deficiency disorders can develop, e.g., rickets in young animals & osteomalacia in adults, milk fever, etc.
b) Co - Needed by microbes to synthesize vitamin B_{12}.
c) I - Deficiencies in the Northwest & Great Lakes regions because of low I in the soil. The use of iodized salt would be the most convenient way to provide I.
d) Others? - Forages are relatively high in many minerals (e.g., Cu, Fe, Mg, Mn, etc.), but grains are usually very low in many minerals.

4) Vitamins:

a) Rumen microbes can synthesize vitamin K and B vitamins - Meeting most of the needs.
b) Sun-cured forages contain large amounts of vitamin D, vitamin E, and β-carotene.
c) Vitamin A - Can be stored enough for 2 to 4 mo., but would be depleted quickly without dietary Vitamin A.

5) Water:

   a) Nonlactating cows consume about 3 parts water for 1 part dry matter intake.
   b) Lactating cows need additional 0.1 gal/d for each 1 lb of milk produced.
   c) Affected by environmental temperatures - 8, 8-9, 10, 11-12, 13-14, and 15-19 gal/d expected water intake by a 1,200-lb cow as the temperature increases to < 40, 50, 60, 70, 80, and 90°F, respectively. (& + 0.1 gal/1 lb milk produced.)

E. Summer

1) Spring calving cows - Should calve early enough so that calves will be 1 to 2 mo. old by turnout to pasture.
2) Milk production - Average about 10 to 25 lb/day over a 175- to 200-day lactation, but the maximum during the first 2 mo. after calving & then declines.
3) Pasture will supply most of the nutrients needed.
4) Hay feeding on lush legume pasture may help control bloat.
5) Need minerals (free-choice) - e.g., A mixture of 1 part bone meal or 1 part dical with 1 part plain salt. Can include both, but either of these Ca and P sources mixed with salt are satisfactory. Salt may also be fed free-choice, block, or granular salt.
6) If pasture is short or inadequate, supplemental energy will be needed - Use silage, hay or both, e.g.:

   a) 15 lb of corn silage/head/d will substitute for about ⅓ of the pasture acreage normally needed; 30 lb/day will make up for ⅔ of the usual pasture acreage.
   b) 5 to 10 lb of a good quality hay/head/d will give the same results.

F. Winter

1) When grazing forage is not available, can feed hay, crop residues, or silage:

   a) Average quality forages (7 to 8 + % CP) are adequate as the main or sole feed.
   b) Poor quality forages may need supplementation with energy or protein sources.
   c) Provide daily roughage in one or two feedings & supplement at a single feeding - At least half of the ration should be fed in the evening during cold weather.

2) Spring calving cows? - No more than about 15% of fall weight should be lost through calving & until grass is ample in the spring. Cows normally lose about 100 to 130 lb at calving.
3) Dry cows wintered on dry grass pastures? - Should be fed 1½ to 2 lb of 40 to 44% CP protein supplement, and if additional energy is needed, provide 1 to 2 lb of grain along with a protein supplement.
4) Fall calving cows on dry grass pasture? - Protein supplement and energy higher than those mentioned may be needed.

5) Use legume hay as a protein supplement? - About 3 lb = 1 lb of 40 to 44% CP supplement.
6) Dry cows on harvested feeds?

    a) Total dry feed allowance: 1.50, 1.75, and 2.0-2.5 lb/100 lb Body Weight for cows in "fleshy, average, and thin conditions," respectively.
    b) Supplement? - Depend on the forage used, but 1½ to 2 lb of 40 to 44% CP supplement will usually be adequate even with low-quality forages.

7) Adjustments to typical daily intakes? - Should be adjusted based on:

    a) The body condition scores of cows (Table).
    b) Environmental temperature:

        (1) The lower critical temperature (LCT) for beef cows with an average dry winter hair-coat thickness is about 20°F.
        (2) See the table on "Additional energy needs by 1,000-lb pregnant cow (Bowman & Sowell, 1998)."

8) The use of urea?

    a) Can be used as the only source of supplemental protein source when cows are wintered on corn silage.
    b) To supplement low-protein roughage? - Better to use with a 20 to 25% CP supplement that contains some grain & molasses as readily digestible carbohydrate to aid in the utilization of urea.

Body Condition Scoring in Beef Cattle

BCS	Description
1 Emaciated	Extremely emaciated, bone structure of shoulder, ribs, backbone, hips and pelvic bones is easily visible and sharp to the touch, tailhead and ribs are very prominent, no detectable fat deposits, little muscling
2 Poor	Somewhat emaciated, tailhead and ribs less prominent, backbone still sharp to the touch, some evidence of muscling in the hindquarters
3 Thin	Ribs are individually identifiable but not quite as sharp to the touch, some palpable fat along spine and over tailhead, some tissue cover over rear portion of ribs
4 Borderline	Individual ribs are no longer visually obvious, backbone can be identified individually by touch but feels rounded rather than sharp, some fat covers ribs and hip bones
5 Moderate	Good overall appearance, fat cover over ribs feels spongy, and areas on either side of tailhead have some fat cover
6 High moderate	Firm pressure now needs to be applied to feel backbone, fat deposits in brisket, over ribs and around tailhead, back appears rounded
7 Good	Fleshy appearance, thick and spongy fat cover over ribs and around tailhead, some fat around vulva and in pelvis
8 Fat	Very fleshy and overconditioned, backbone difficult to palpate, large fat deposits over ribs, around tailhead, and below vulva
9 Extremely fat	Smooth, blocklike appearance, tailhead and hips buried in fatty tissue, bone structure no longer visible and barely palpable

Source: Richards et al., 1986. J. Anim. Sci. 62:300. (Cited by Bowman & Sowell, 1998)

°F below LCT	Additional Mcal needed/d
0	0
5	0.9
10	2.0
15	3.2
20	3.6
25	4.5
30	5.4
35	6.4
40	7.3

MANAGEMENT OF CALVES

1. General

- Just like some other species, need proper nutrition for calves before the animal is born - Data from the Western US [Cited by Bowman & Sowell (1998)]:

    1) Low dietary protein intake in the dam? - Caused weak calf syndrome & resulted in the deaths of young calves.
    2) Cow herds that consumed an avg. of 2 lb CP/d and herds consuming hay with at least 10% CP during the prepartum had no problem, whereas those fed the hay with less than 10% CP had serious weak calf problems.

2. Creep feeding

A. Creep feeding:

1) Definition? Some means of providing additional nutrients to calves, which can be hay, grain, or mixed rations - e.g., 30% cracked corn, 30% cracked oats, 30% cracked barley, 5% molasses, and 5% soybean meal.
2) Generally, milk production is enough during the first 100 days or so of postpartum to support growth of the calf.
3) Milk production starts to decline after that, and the calf obviously needs additional nutrients. Thus, may need creep feed or would be a beneficial effect of creep feed!?

B. Advantages?

1) Heavier wt calves at weaning (. . . can add 25 to 50 lb?).
2) Improves the condition & uniformity of calves at weaning.
3) Less wt loss by cows.

C. Disadvantages?

1) Requires extra labor, equipment, feed, and management.
2) Higher feed costs - Perhaps, needs 7 to 10 lb feed/lb of gain.
3) Replacement heifer? May become too fat, which may reduce milk production later because of the impairment of milk-secreting tissue development, and also may increase calving difficulty!
4) Over-fattened calves may gain slowly during the first 2 to 3 mo. once moved into the feedlot, and also may finish at lighter weight.
5) Mask the milking ability of the cow & affect her maternal ranking based on the weaning weight.

D. Profitable to use creep feeding? Might be profitable when pasture is short or quality is poor, and obviously when calf prices are high relative to feed prices!

E. Implanting?

1) Implanting both at 60 to 90 days (150 to 200 lb) will boost weaning weight by 20 to 40 lb in addition to that obtained by creep feeding.
2) Breeding heifers? Not recommended, even though implanted at recommended doses at 3 mo. of age may have no effect on the breeding performance!

3. **Weaning**

A. Commonly weaned at 6 to 9 mo. of age, which fits well with vaccinations and performance testing for replacement heifers, or for feeder calf sales.
B. Advantageous to wean earlier?

1) Calves from first-calf heifers? - Reduces stress and increases the possibility of earlier heat and conception.
2) Fall-dropped calves? - Reduces expensive harvested feed for the cow.
3) Bull calves? - May begin riding other animals at 7 to 8 mo. of age, so . . .

C. Generally, "early weaning" is a technique designed to improve rebreeding of the first and second calf heifers because suckling delays the onset of estrus. But, should not be weaned before 5 mo of age unless there is an emergency!
D. At weaning time:

1) Keep calves out of sight and sound of calves if possible - The cow would dry off more effectively!
2) Calves suffer less stress and shrink if they are eating a creep feed when weaned.
3) Clean water & quality hay - Should be made available, and eventually should be fed from bunks to reduce adaptation time when they reach the feedlot.

E. Preconditioning calves before they leave the production site

1) Preconditioned calves? - Better health & more efficient, thus beneficial for the feedlot operator. Often, $3 to 5/cwt premium to the producer!
2) May vary somewhat in different areas of the country, but generally:

a) Mandatory regulations:

(1) Wean & start on feed/grain no less than 30 d before the sale or shipment date.
(2) Adaptation/adjustment to feed bunks and water troughs & start on a similar ration they will get at the feedlot.
(3) Castrate, dehorn, and treat for grubs no less than 3 wk before the sale.
(4) Vaccinate for infectious bovine rhinotracheitis (IBR), para-influenza (PI_3), Pasteurella spp. and Clostridial spp. no less than 3 wk. before the sale.

b) Optional regulations?

(1) Treat for worms, and vaccinate with leptospirosis before the sale.
(2) Vaccinate with bovine virus diarrhea (BVD), and Haemophilus somnus (bovine respiratory disease) no less than 3 wk prior to the sale date.

4. **"Stocker Cattle"**

A. Refers to weaned calves (steers or heifers) that are forage-fed for a period of time before being sold to enter the feedlot - Generally thin & carrying little finish.
B. May be bought in the fal?

1) To be wintered on high-roughage diets in drylot & sold in the spring for further pasture grazing, or enter a feedlot finishing program.
2) To be grazed on small winter grain forage (usually wheat or winter oats) or grass (fescue) pasture - Then, may enter the feedlot as 600- to 800-lb feeder cattle.
3) To be grazed stock fields (corn/sorghum), and then moved to a drylot for the winter, fed corn or sorghum silage with some supplement, and then finished on a high-energy ration in the drylot for slaughter in the summer or fall.

5. **"Backgrounded Cattle"**

A. Weaned calves placed in a drylot or pasture (or both) with more emphasis on growing than described for the stocker calf.
B. Fed a grain in addition to a roughage to reach around an 800-lb weight and then moved into a high-energy finishing ration.
C. Should be in good health and bunk broke & ready to go on a full feed of grain.

HEIFER DEVELOPMENT AND MANAGING BULLS

1. **Heifer Development**

A. Creep Feeding? - Generally not recommended to creep feed replacement heifers.

1) Creed feeding - May enhance growth but masks the effect of cow milk production, which is used to select females.
2) Not marketing the increased weight & not increasing the value of replacement heifers.

B. Developing replacement heifers

1) Expected to calve for the first time as 2-yr-olds? - Should be developed to reach about 55 to 65% of their expected mature wt at 15 mo of age.
2) Would depend on the breed type & environment, but 0.75 to 1.0 lb gain/d from 7 to 15 mo of age.

3) A slower rate of gain may delay puberty and reduce reproductive efficiency, whereas a faster rate of gain may impair mammary development!

C. When spring born heifers are 7 to 15 mo old & are not pregnant, should gain 100 to 200 lb depending on the breed type & weight during the first winter.
D. Pregnant heifers? - Should enter their second winter at 750 to 850 lb, and should weigh 900 to 1,000 lb at calving.
E. During the third winter & pregnant 3-yr -olds should not lose more than 5 to 10% of their fall wt. Maintaining adequate body condition is essential for pregnant heifers!

2. **Managing Bulls**

A. Young bulls

1) Should be creep fed and then full fed a high energy ration (70 to 85% concentrate) from weaning to 12 to 14 mo of age:

a) Should feed (dry feed) about 2½% of the body wight & should gain 2½ lb/day.
b) Should be ready for use at 15 to 18 mo of age.

2) About 15 mo to 3 yr old - Should gain 1¾ to 2¼ lb & consume dry feed equal to 1⅓ to 2¼% of their body wt, with the proportion of roughage increased after the 1st yr.

B. Mature breeding bulls - Usually can maintain condition on the same kind of pasture and wintering management provided for the cow herd.

1) Winter feeding?

a) One-half lb of grain/l00 lb body weight with protein supplement and free choice roughage - Adjust grain to attain desired condition.
b) Using corn silage? - Adjust grain and protein supplement as needed.
c) Free-choice minerals (salt, Ca, P, and trace minerals if poor quality forage), and 20,000 units vitamin A/day if any question on the content in feed.

2) Summer feeding? - Similar to cow herd with free-choice minerals and pasture, and supplement energy only when needed to maintain satisfactory condition, specially young bulls!

GRAZING MANAGEMENT

1. **General**

A. The greatest challenge for the beef cow producer? - To reduce purchased feed costs & increase profitability per cow.

B. One way is to achieve goal is to maximize the use of inexpensive forages, which may not occur under most growing conditions in North America, thus:

1) Use improved pastures early or later in the growing season is the one of the best methods to match forage quality & animal demands.
2) Determining/maintaining the optimum stocking intensity is important in the long-term profitability.

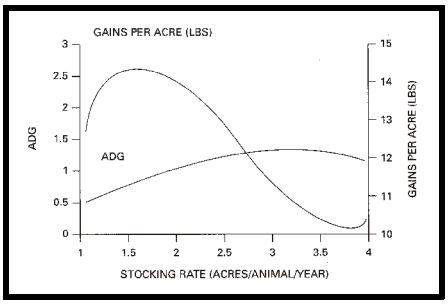
2. Improved Pastures?

A. Pastures with introduced forage species are used throughout the US - Higher nutrition values vs. native forages.
B. Some examples:

1) Use of perennial ryegrass (cool season) to meet the winter nutritional needs of grazing cattle & reduce the use of protein supplement in the South.
2) Extensive use of crested wheatgrass for lactating beef cows during in the early spring throughout the western US - Can prevent early spring use of native ranges, which may deplete cool-season grasses.

C. Irrigated pastures can provide a high-quality forage to beef cows following calving, which can improve conception rate.
D. Mixtures of grasses and legumes? - May improve performance vs. poor grass stands, and also legumes eliminate the need for N fertilizer.

3. Stocking Intensity



A. As stocking rate is increased, productivity per animal may decrease but productivity per acre would be increased (Bowman and Sowell, 1998).
B. Consequences of high grazing intensity?

1) Remove thebest quality-forage early & only poorer-quality forage would be left behind, and also may increase the loss from some poisonous plants.
2) More time & energy would be spent in grazing.
3) Reduced individual animal performance simply because of the reduced forage intake & quality, even though, again, it can increase higher gains per acre.
4) Lower pregnancy rate, calf crops, etc. because of the quantity/quality of forages.

4. Grazing Systems

A. Should manipulate beef cattle to maintain or improve range conditions - Gradual improvement in forage conditions eventually increases the carrying capacity.
B. Continuous grazing - Most common scheme:

1) Animals are left to graze one area for the entire grazing season or sometimes the entire year.
2) Total production/acre is lower vs. other systems, but maintenance costs are low.
3) With managed stocking intensity, can maintain the range condition and meet the nutritional needs of animals better than other systems.

C. Deferred rotational grazing:

1) Used to allow desirable plants to achieve some phenological stage, such as flowering or seed maturity, without being grazed.
2) Example? A 4-pasture deferred rotation - One pasture would not be grazed from spring to mid-summer, and another pasture would not be grazed the following year for the same period , and the deferment would be rotated through all pastures after 4 years.
3) Superior to continuous grazing in improving range condition!?
4) Problems? - Reduce individual animal performance and increase supplementation costs during the deferred period.

D. Rest rotation grazing - Used extensively in the western US:

1) Usually use three to five pastures, and one pasture is not grazed for an entire year, while a single herd utilize other pastures.
2) One-year rest is rotated across all pastures in different years.
3) Better vegetation response vs. continuous grazing, but can reduce animal performance.

E. Short duration grazing - Developed in France with daily cattle:

1) Uses a wagon wheel arrangement of pastures with a central watering point.
2) Usually, with, at least, eight pastures, but some systems have as many as 40 paddocks.
3) Each pasture is grazed intensively (two- to three-fold increase vs. normal intensity) for 2 to 3 days, and then not grazed for several weeks.
4) Some pastures may be grazed two or three times during the grazing season.
5) Best on highly productive soils with grazing-resistant plants (. . . similar palatability).
6) Drawback? - The system leaves no emergency forage for drought conditions. With no regrowth during the resting period, no forage for the next grazing period.

BEEF CATTLE TYPES AND GROWTH

1. **US Cattle feeding Industry (finishing)**

A. Concentrated in the Great Plaines of the US with some midwestern & western states.

B. Thirteen states, AZ, CA, CO, ID, IL, IA, KS, MN, NE, OK, SD, TX, and WA, accounted for about 86% of cattle-on-feed in 1994.

2. **Cattle Types & Growth**:

A. Receiving feeder calves from cow herds across the United States & Mexico with many exotic breeds in recent years, which can add to the variation in the size, body type, and also potential growth.

B. NRC includes medium- & large-frame size in the prediction equations for estimating the nutrient requirement and feed intake:

1) Large-framed - Produce Choice carcasses at live wt of more than 1,200 lb.
2) Medium-framed - Produce Choice carcasses at 1,000 to 1,2000 lb'
3) Small-framed - Produce Choice carcasses at < 1,000 lb.

C. Muscle thickness standards - Indicate the difference in muscle-to-bone ratio with similar fatness: No.1 = Thick, No. 2 = Moderate, and No.3 = Thin.

D. Age, frame size, and muscle thickness of cattle fed to "0.53 in." fat - See the table.

1) Increasing age & decreasing frame size - ↓ days on feed.
2) Slaughter wt & carcass wt - Heavier for long yearlings vs. calves & yearlings.
3) Increasing frame size - Heavier slaughter wt & hot carcass wt.
4) No differences in days on feed between muscle thickness No. 1 & No. 2, but No. 3 needed more days to reach 0.53 in.

Effects of some factors on steers fed to 0.53 inches fat thickness [Dolezal et al. (1993). Cited by Galyean & Diff (1998)]

Item	Days on Feed	Slaughter Wt (lb)	Hot Carcass Wt (lb)	Dressing (%)
Age class				
Calf	251[a]	1,134[b]	712[b]	62.6
Yearling	166[b]	1,181[b]	737[b]	62.2
Long yearling	98[c]	1,301[a]	816[a]	62.7
Frame size				
Large	214[a]	1,421[a]	897[a]	63.2[a]
Medium	163[b]	1,176[b]	739[b]	62.8[a]
Small	139[c]	1,024[c]	631[c]	61.5[b]
Muscle thickness				
No.1	139[b]	1,181[b]	741[b]	62.7
No.2	156[b]	1,197[ab]	749[ab]	62.4
No.3	220[a]	1,239[a]	774[a]	62.5

abcLS means within the same column and item without common superscripts differ ($P < 0.05$).

E. Frame size & muscle thickness combinations on days on feed to reach 0.53 in. of fat thickness - See the table.

1) As frame size ↑, days on feed ↓.
2) As animal age ↑, need fewer days.

Days on feed required to reach 0.53-inch fat thickness by steers [Dolezal et al. (1993). Cited by Galyean & Diff (1998)]

Frame size & Muscle thickness	Age Class		
	Calf	Yearling	Long Yearling
Large No.1	235	162	105
Large No.2	247	194	135
Large No.3	368	286	189
Medium No.1	196	148	84
Medium No.2	254	142	91
Medium No.3	272	198	78
Small No.1	185	76	55
Small No.2	213	92	42
Small No.3	287	198	100

4. **Effect of Breeds?**

A. Yearling British-cross steers (Angus x Hereford about 16 mo of age) - Need about

112 d on high-concentrate diet to reach Choice quality grade, and feeding beyond 112 d had no effect on the grade or palatability; and increased waste fat.

B. Angus steers following a growing period of 150 d at 1.3 lb/d - Needed only 45 d to reach Choice grade, but need more time to achieve acceptable tenderness.
C. Large breeds (e.g., Chiaina) - Quality grade increased up to 128 d on feed, but reached plateau thereafter; Just increased fat with no changes in the quality grade.

SYSTEMS FOR GROWING AND FINISHING BEEF CATTLE

1. General

A. Systems in the United States - Vary by the location and may be affected by feed sources and climate.
B. The eastern and southeastern United States - Support most of the cow-calf production with calves sold at weaning to go either directly to the feedlot or to a backgrounding operation.

1) Increasing interest by cow-calf producers to retain ownership of the calf through the growing period or through slaughter in recent years!
2) In the United States, most cattle go through a backgrounding period after weaning before placement in a feedlot on a finishing diet.

C. Difficult to classify, but the growing system can be classified into two:

1) Intensive systems - Cattle are placed directly in the feedlot.
2) Extensive systems - Cattle are grazed on forages for varied lengths of times, or fed milled diets in a drylot.

2. Intensive Systems

A. Some advantages?

1) Can reduce the cost of gain - Because of the use of less expensive source of energy, cereal grains, and the cost of mixing/handling concentrates vs. roughages.
2) Cereal grain feeding can decrease manure production vs. ad libitum consumption of roughage-based diets.
3) Intensively fed calves are generally more efficient than calves subjected to extensive production systems.

B. A major disadvantage? Intensively fed cattle would put on more fat and finish at lighter weights, thus producing light carcasses. But, with large-framed cattle, can produce carcasses within an acceptable range for the packing industry.
C. Limit or programmed feeding - Alternative?

1) Feed a high-concentrate diet to provide a specified rate of gain.

2) Using this approach to achieve similar gains may improve feed conversion dramatically vs. those fed a corn-silage-based diet.
3) No detrimental effects on finishing performance.

    a) But, may increase incidence of liver abscesses by feeding all-concentrate diets during both the growing and finishing phases.
    b) Concentrate or roughage content/amount may be important in using this approach, even though some data indicating that the percentage of concentrate during the growing phase did not greatly affect finishing performance or carcass traits.

3. **Extensive Systems**

A. Grow cattle at low-moderate rates of gain (1.75-2.5 lb/day) using roughage-based diets.
B. Cattle - Older & yield heavier carcasses vs. those given a finishing diet after weaning.
C. Roughage and yardage costs can be a major disadvantage, but the cost can be reduced with grazing forages:

1) Fescue pastures

    a) Cattle previously grazed tall fescue pastures can exhibit signs of heat stress and display rough hair coats - Perhaps, because of endophyte-infected fescue pastures during periods of high ambient temperatures or humidity.
    b) When cattle are placed in the feedlot later in the fall when these conditions are not prevalent, no sacrifice in performance may be noted.
    c) Anabolic agents (estradiol 17-β) may improve performance by steers grazing endophyte-infected fescue - But, still not compatible with ones grazed noninfected varieties & low-endophyte-infected fescue.

2) Stockpiled forages - Let cattle graze stockpiled forages during the winter to reduce the labor & equipment costs, e.g.:

    a) Grazing stockpiled tall fescue from November to April in Virginia gained 0.75 lb/day and required only 527 lb of hay-stocker fed during 36 days.
    b) Similar performance between feeding orchard grass-alfalfa hay vs. stockpiled fescue-alfalfa, but more stored feed was required.

3) Winter wheat pasture

    a) Cattle that have grazed annual winter wheat pasture generally perform well in the feedlot - Obviously, differences among pastures though!
    b) One advantage? - No need for supplementation of the cattle to achieve adequate gains . . . other than a mineral supplement.
    c) Disadvantage - A possibility of bloat:

(1) Feed additives like poloxalene and the ionophore monensin help to prevent bloat in cattle grazing wheat pasture.
(2) Preferable to include these products in some type of supplement & not with minerals, so that the animals receive the daily recommended amounts.

d) Wheat varieties are usually selected based on non-animal performance factor, and some data indicate that selecting for grain yield can reduce beef gain per acre.
e) Sometimes, cattle may need to be fed in a drylot before being placed on the wheat pasture.

4. **Systems & Performance?**

A. Beef cattle producers in the United States - Have almost limitless means of feeding cattle from weaning to slaughter.
B. A possibility of taking advantages of "compensatory growth?"

1) Some would pay a premium for cattle subjected to a period of restricted growth because of the compensatory response.
2) Must consider the severity, nature, and duration of the restriction though!

C. Nebraska's computer simulation evaluated the effect of post-weaning production systems on performance and carcass composition of different biological types of cattle:

1) The model used:

a) Steers from Fl crosses of 16 sire breeds mated to Hereford and Angus dams.
b) Steers growing under the following "nine backgrounding systems" & finished at either a low (2.2 lb) or high (3.0 lb) ADG:

(1) High ADG (1.98 lb) for 111, 167, or 222 days.
(2) Medium ADG (l.l0 lb) for 200,300, or 400 days.
(3) Low ADG (0.55 lb) for 300 or 400 days.
(4) 0 day backgrounding.

2) Results?

a) Considerable flexibility exists in the choice of post-weaning production systems for several genotypes of steers to produce acceptable carcass composition and retail product.
b) Carcasses with a specified composition, retail product, or quality can be produced from a mixed group of steers fed and managed similarly from weaning to slaughter.

MANAGING NEWLY RECEIVED CATTLE

1. General

A. Bovine respiratory disease (BRD) in newly weaned or received cattle can be a significant economic problem:

1) Death losses may range from 1.5 to 2.7/100 animals marketed, and ⅔ - ¾ may be attributed to respiratory disease.
2) Two factors contribute to the high incidence of BRD in newly received, lightweight (e.g., less than 400 to 500 lb) cattle:

a) Stresses associated with weaning & normal marketing - Negatively affect the immune system when the animal is often challenged by infectious agents.
b) Low feed intake by stressed calves - Averaging about 1.5% of BW during the first 2 wk after arrival.

B. Practices to offset negative factors that affect the health of newly weaned or received cattle include: 1) preconditioning, 2) on-ranch vaccination programs, 3) nutritional management after arrival at the feedlot, and 4) prophylactic medication.

2. Energy

A. Stressed calves reduce feed intake, and also tend to prefer & eat greater amounts of a high-concentrate than a high-roughage diet.
B. Receiving diets with high-concentrate can increase the severity of morbidity (days of medical treatment per calf purchased).
C. Feeding alfalfa or good-quality grass hays during the first week of the receiving period can offset the negative effect of high-concentrate receiving diets on morbidity.
D. An effective receiving program? - A diet with about 60% concentrate, with either free-choice or limited quantities of hay (approximately 2 lb/day) during the first week.
E. Feeding good-quality hay plus protein supplement may be sufficient, but calves may not fully compensate for lower gains during the receiving period.

Effect of protein on performance by calves during a 42-day receiving period (Galyean et al., 1993)

	Crude protein, %				
Item	12	14	16	Contrast	SE
Receiving period performance					
No. of calves	40	40	40	-	-
Initial BW, lb	412.4	409.2	403.3	-	2.6
Day BW, lb	520.1	536.6	537.2	-	5.5
Daily gain, lb					
0 to 21 days	1.50	1.85	1.97	-	0.34
21 to 42 days	3.52	4.23	4.40	Ln	0.21
0.42 days	2.51	3.04	3.19	Ln	0.11
Daily DM intake, Ib/steer					
0 to 21 days					
Hay	1.34	1.36	1.34	-	0.05
Concentrate	5.84	6.36	6.67	-	0.34
Hay + concentrate	7.17	7.72	8.01	-	0.35
21 to 42 days	12.55	12.40	13.30	-	0.39
0 to 42 days	9.86	10.06	10.64	Ln	0.27
Feed to gain ratio					
0 to 21 days	5.64	4.72	4.35	-	0.94
21 to 42 days	3.61	2.95	3.04	Ln	0.17
0 to 42 days	3.95	3.32	3.35	Qd	0.08
Calves treated for BRD,%	37.5	22.5	47.5	-	-
Mortality (no.)	2	1	0	-	-
Postreceiving performance					
Daily gain, lb	3.49	3.40	3.21	-	0.18
Daily DMI, lb/steer	15.37	15.76	15.49	-	0.47
Feed-to-gain ratio	4.44	4.66	4.83	-	0.16
Overall performance					
Daily gain, lb	3.00	3.22	3.20	-	0.12
Daily DMI, lb/steer	12.62	12.91	13.07	-	0.33
Feed-to-gain ratio	4.23	4.01	4.09	-	0.09

3. Protein

A. Effect of feeding 12, 14, or 16% CP for stressed calves (19.5 h in transit, 6.8% shrink) during the initial 42-d & then fed a 14% CP, 85% concentrate diet (Table).

    1) Increased gain and DM intake linearly with increasing CP during the 42-d receiving period.
    2) Ones fed the 12% CP diet compensated during the subsequent 42-d period, thus no effect on performance during the 84-d trial.

B. A supplemental source of CP may not be crucial in receiving diets as long as a natural source is used, perhaps, because of a low capacity for protein deposition during the first wk or two after arrival due to low feed intake?
C. One exception? - Corn-silage-based receiving diets, which would likely supply a fairly large amount of ruminally degraded N, and improved gain and efficiency were reported when blood meal was the source of supplemental protein vs soybean meal.
D. Practical receiving diets based on hay & other dry roughages - ≥ 14% CP!

4. **Minerals & Vitamins**

A. Received cattle? May increase the need for K, but no effects on others. Perhaps, may need to increase the concentration of most minerals because of low feed intake?
B. Zn, Cu, Cr, and Se - May affect the immune function.
C. No consistent effects of B vitamin supplementation on performance and health of newly weaned or received cattle, thus, little economic justification for practical receiving diets?
D. Vitamin E - Feeding 400 to 800 IU/day has increased performance and decreased morbidity in some field studies.

5. **Feed Additives**

A. Ionophores - Often added to receiving diets to control coccidiosis, which can result in the decrease in feed intake, but the effect can be minimized by the choice of ionophore or, with monensin, by decreasing its dietary concentration.
C. Antimicrobial agents - Often added to feed or water of newly received cattle to reduce morbidity:

    1) Chlortetracycline and oxytetracycline in the feed or water? Effective in controlling BRD, especially when morbidity and mortality are low.
    2) A combination of oxytetracycline and sulfadimethoxine as a mass medication treatment for newly received cattle? - Stressed calves decreased morbidity from 63.3% in control to 7.1 % in treated group in one study.
    3) Tilmicosin phosphate? - Reduced the percentage of calves treated for BRD from 46.4 to 0% in one trial and from 32.8 to 12.1% in a second trial in one study.

D. Prophylactic medication of newly received, stressed cattle can be useful in decreasing the incidence of BRD & other adverse conditions.

STARTING CATTLE ON FEED & FEED BUNK MANAGEMENT

1. Transition Period

A. The primary goal of the cattle feeder during the first few days after arrival? - Minimize disease and death loss!
B. Starting cattle on feed? - Refers to the transition between the receiving or growing diet and the final, high-grain finishing diet.
C. No standard way of getting recently purchased cattle on feed.
D. Cattle grown on roughage-based diets - Change the diet from mostly roughage to mostly concentrate gradually.
E. Cattle grown on concentrate or programmed feeding program - No need for step-up in the amount of dietary concentrate but need to increase the quantity of diet.

2. Transition from Grazing or a Roughage-Based Growing Diet

A. Accomplished by using a series of step-up diets to increase the amount of concentrate. A smooth changeover can avoid excess consumption of concentrate, which can lead to acidosis and decreased feed intake.
B. Traditional approach?

    1) Feed a relatively low-concentrate diet (40 to 50%) as the starter diet, and in some cases, provide hay on a free-choice basis for the first few days.
    2) Transition to the final high-concentrate diet (90% + concentrate):

        a) Make in steps of l0 to 20% concentrate over a period of 21 to 28 days - Each step may consist of 3 to 7 days.
        b) Too abrupt changes are likely to cause cattle to decrease feed intake because of acidosis - May have to step back to the previous diet.

C. Another approach? (Simply because most commercial feedlots feed 2-3 times/day)

    1) Gradual dietary concentrate changes by feeding the next diet in the step-up program as the second or third feeding of the day.
    2) On the following day, the next step-up diet may consist two of the three daily feedings, and a complete transition over a 3-day period.
    3) Depending on intake, cattle can be held at any step for a few days or the transition can continue.

D. Another approach? - Allow cattle to reach ad libitum intake of a moderate concentrate (60%?) starter diet, followed by a gradual increment, 10% daily for example, until the final high-concentrate diet of 90% + concentrate is achieved.
E. Sound bunk management is critical to any of the approaches to start cattle on feed.

1) During the transition to higher dietary concentrate, may be beneficial to have some feed in the bunks to prevent overconsumption.
2) Monitor feed intake very closely, or intake prediction equations can be used to determine whether feed intake is meeting appropriate targets.

3. Feedbunk Management

A. Feed bunk management is one of the most critical jobs in the feedlot.

B Once started on feed, the approach for bunk management changes from the one used during the step-up period:

1) Monitoring of feed intake closely to ensure expected intake is still important.
2) But, once cattle are on the final high-concentrate diet, the main objective might be to achieve a relatively constant intake over time.
3) Ideal? - "*The last mouthful of feed consumed as the feed truck is dumping additional feed in the bunk!*"

C. "Bunk reading" - Critical to ensure that cattle are not short on feed, thus hungry, or fed too much so that excessive feed remains in the bunk, which becomes stale.

D. Recent trends/approaches?

1) Try to achieve a clean bunk in somewhat less that a 24-h cycle - i.e., Feed bunks should be read during the late night hours.
2) Also, constantly challenge cattle to increase their feed intake - e.g.:

a) If a pen of cattle has a clean bunk at 12:00 A.M., the next day's feed call or allowance might be increased by 0.5 to l.0 lb/animal.
b) If the pen fails to clean up the new allotment of feed, feed would be reduced back to the original allotment.
c) Over a period of 2 to 3 days - If the pen cleans up this new amount of feed, cattle are once again challenged with a higher amount.

E. To allow cattle to achieve maximum feed intake with minimal day-to-day variance, a consistent bunk reading is must and typically involves the use of computerized records for each pen to assist the bunk reader!

FINISHING DIETS FOR MARKET CATTLE

1. General

Composition of typical beef cattle finishing diets (% DM) [Galyean & Duff (1998)]

Ingredient	Processed Corn & Dry Roughage	Whole Corn & Corn Silage	Dry-rolled Corn & Wet Corn Gluten Feed
Roughages			
Sudan grass hay	4	-	8
Alfalfa hay	6	-	-
Corn silage	-	10	-
Grain and grain by-products			
Steam-flaked corn	74.5	-	-
Dry-rolled corn	-	-	52.5
Whole shelled corn	-	71	-
Wet corn gluten feed	-	-	35
Liquid feeds			
Molasses	5	-	-
Condensed distillers solubles	-	4	-
Fat	3	-	-
Supplement*	7.5	15	4.5

* Supplies Ca and P sources, urea and/or natural protein, trace minerals, vitamins, and feed additives.

A. The ultimate purpose of finishing process? - Obviously, produce beef that is desirable to the consumer.

B. Finished cattle - Mostly marketed between 1 to 2 yr of age with over 1,000 lb.

C. Some cattle may go into the finishing feedlot at 200 to 300 lb at a few months of age (calves) and some may weigh 600 to 800 lb (yearlings), while other may weigh 900 lb or more & older than 1 yr of age.

D. Because of the differences in kind of cattle being finished, obviously the nutrient requirements differ - See the table for some examples of finishing diets.

E. Complete (mixed) rations for finishing cattle generally need:

1) CP - 9 to 14% depending on age, size, and growth rate.
2) Energy - Need high concentrate diets (TDN = 65 to 85% or NEg = 0.40 to 0.65 Mcal/lb), which can improve performance & carcass traits, and cost less, but more prone to develop acidosis, founder, and liver abscesses.
3) Ca - 0.3 to 0.6%. Supplemental Ca is must when using high-concentrate diets & limited access to forages. Ca:P ratio of 2:1?
4) P - 0.2 to 0.4%. Grains and high-protein supplements are generally high in P, thus little or no need for supplementation in high-concentrate diets!?

2. Roughage in Finishing Diets

A. General:

1) Although some feedlots use all-concentrate diets, usually, high-concentrate finishing diets contain small amounts (3 to 15%) of roughage.
2) On the energy basis, roughage can be one of the most expensive ingredients in finishing diets.
3) Can be an important component of feedlot diets and have a large influence on ruminal function, e.g., the low dietary roughage content has been associated with digestive upsets such as acidosis & liver abscesses.
4) Common sources? Alfalfa hay, grass hays, silages (corn, wheat, and grasses), and by-product feeds (e.g., cottonseed hulls).

B. Roughage inclusion rate can affect cattle performance - Some examples:

1) Faster, more efficient gains by cattle fed either 5 or 10% roughage compared with those fed 0 or 15% roughage in steam-rolled wheat diets.
2) With 0, 3, 6, and 9% 50:50 mixture of alfalfa and corn silage in high-moisture corn and dry-rolled sorghum diets:

a) Observed quadratic effects on DM intake & daily gain, and gain was maximized at 9% roughage.
b) But, reduced the efficiency as dietary roughage increased from 0 to 9%.

C. Source

1) Often, the source is as important as the roughage content & both can interact with grain processing; The effect of source on performance in cattle fed high-concentrate diets may depend on the grain-processing method.
2) Matching sources and amounts with grains for optimal utilization in high-concentrate diets is desirable, even though the data are limited.

D. Effects of roughage on digestion and passage

1) Effects of roughage in high-concentrate diets - e.g., increasing roughage can increase passage rate of grain in the rumen.
2) A source of roughage affects digestion and passage, but the effect could vary with the type of grain in the concentrate.
3) High-grain (starch) diets:

a) Often decrease digestion in the rumen, thus shifting it to the large intestine.
b) The LI may not be able to compensate fully for the ↑ fiber load - Thus, ↓fiber utilization may partially explain ↓ feed efficiency with increasing roughage?!

4) With highly processed grains, which are digested extensively in the rumen, little starch would reach the LI, and compensatory digestion of fiber in the LI could proceed without negative associative effects of starch.
5) With unprocessed grains, more starch would reach the large intestine, which might have negative effects on fiber digestion in that organ.
6) The amount & source of roughage may influence small intestinal digestion of starch - Increased pancreatic α-amylase activity in forage-fed vs concentrate-fed calves at equal energy intakes has been reported.

3. Grains, Grain Processing, and Other Feedstuffs

A. Grain sources to use? - Depend on many factors including location of the feedlot, feed availability, cost, equipment, and palatability.

1) Corn - Readily available in the Midwestern and upper Great Plains states.
2) Sorghum grain/milo - Commonly used in Southern Great Plains states.
3) Wheat, barley, or oats - May become available during certain periods of the year or certain locations.
4) Others? - Recent advances in the technology may lead to the increased use of alternative grains, e.g., high-lysine corn.

B. Starch in grains & grain processing

1) Starch granules:

   a) Starch exists in grains as granules in the endosperm, and the properties of starch granules depend on the particular grain.
   b) Highly organized crystalline region contains mostly amylopectin, which is surrounded by a less dense, amorphous region that is high in amylose.
   c) Granules are also embedded in a protein matrix, which, particularly in corn and sorghum, can decrease the potential for enzymatic attack and digestion.

2) Gelatinization:

   a) Occurs with the sufficient energy applied to break bonds in the crystalline region of the granule - e.g., Mechanical, thermal, and chemical agents can initiate the process, but water is necessary.
   b) Processing methods with "heat & moisture" (e.g., steam flaking) can cause extensive gelatinization & rupture of starch granules.
   c) Heating also can denature grain proteins, which could affect starch digestion.

3) Gelatinized grains are typically digested to a greater extent in the rumen and the total tract vs. unprocessed grains.
4) Beneficial effects of processing? - "Inversely" related to the digestibility of the unprocessed grain.
5) Even without processing, barley and wheat are digested well in the rumen, but some processing is needed for the efficient use of sorghum/milo.
6) Bulk density - A practical means of determining the degree of processing, e.g., ↓ bulk density of steam-flaked sorghum from 35 to 18 lb/bu can ↑ both enzymatic and ruminal rates of starch breakdown.
7) Particle size - Affects the rate of digestion; e.g., As particle size decreased in situ, DM and starch digestion for steam-flaked, dry-rolled, and high-moisture corn increased.

☞ Mixing different grains or the same grain processed by different methods? - Can be an effective way to take advantages of different digestion characteristics among grains and grain processing methods?

C. By-products and other feedstuffs

1) Because of lower costs (often), by-product feeds have become important feedstuffs for feedlot diets & others - e.g., whole cottonseed, brewers grains, distillers grains, beet pulp, citrus pulp, soybean hulls, wheat middlings, cull potatoes, and many others.
2) Soybean hulls - Became popular in recent years, and can be used efficiently by feedlot cattle when priced competitively.
3) Depending on manufacturing processes and grains used, the composition of these products can be variable, thus important to determine the composition.
4) Liquid feeds:

    a) e.g., Fat (tallow, animal and vegetable blends, and soap stocks) is commonly added at 2 to 4% of finishing diets depending on the price, and also molasses and liquid by-products of the corn milling industry are commonly used.
    b) Liquid feed - Generally decreases dustiness and often improves palatability.

4. Protein & Other Nutrients

A. Protein

1) Dietary CP content has been increasing in recent years:

    a) Based on the old NRC (1984), CP requirements for finishing beef steers started on feed at 700 lb & gaining 3 lb/d ranged from "8.9 to 11.7%," depending on the BW.
    b) But, based on one survey of nutrition consultants, CP in finishing diets ranged from "12.5 to 14.4%," and added urea ranged from 0.5 to 1.5% of the dietary DM.

2) Improved performance with added protein?

    a) More consistent with the use of ruminally degraded sources of CP (e.g., urea and soybean meal), and limited advantages with rumen undegradable protein sources!
    b) Why? - Highly processed grains are readily fermentable in the rumen, and may increase microbial needs for ruminal N, and N in excess of needs might provide ammonia for the maintenance of acid-base balance by the kidney?

B. Vitamins

1) Vitamin A - Usually recommended & a common approach is to supplement the required doses without considering contributions from feedstuffs.
2) Vitamin E - Commonly added to receiving diets, and also to finishing diets?

C. Minerals

1) Generally, diets are formulated to satisfy the needs for required major minerals (Ca, P, K, S, Mg, Na, and Cl) and trace minerals (Co, I, Fe, Mn, Se, and Zn).
2) Organic trace mineral complexes? - Considerable debate on the merit!

5. Anabolic Agents and Feed Additives

A. Anabolic agents

1) Currently approved implants for growing-finishing cattle? - Estrogen-based, androgen (trenbolone acetate)-based, and estrogen + trenbolone acetate-based.
2) Implants:

    a) Increase the rate of gain, feed efficiency, and carcass weight at Choice grade by 55 to 99 lb.
    b) Typically increase daily protein and fat gain in the carcass. The effects of estrogen + trenbolone acetate-based may be greater than estrogen-based.
    c) Usually, also increase feed intake, i.e., un-implanted cattle usually consume 6% less DM than implanted cattle.
    d) One common procedure? Use an estrogen-based implant initially & an estrogen + trenbolone acetate-based implant as a second implant.
    e) Finishing heifers - Often receive an initial estrogen-based implant and a final androgen-based implant.
    f) Implant programs may increase dietary protein requirements, presumably because of an increased rate of daily protein gain.

B. Ionophores

1) Fed to the majority of finishing beef cattle.
2) Three compounds are approved for use in confined beef cattle diets - Monensin, lasalocid, and laidlomycin propionate.
3) Effects of ionophores on performance?

    a) Monensin - Decreases feed intake, with little change in daily gain, resulting in improved feed efficiency.
    b) Lasalocid - Similar or greater intake with increased daily gain, thus improving the feed efficiency.
    c) Laidlomycin propionate - Tends to have little effect on feed intake, but increased daily gain, results in improved feed efficiency.

C. Other Feed Additives

1) A variety of other antibiotic feed additives are used:

a) Virginiamycin - Approved for use in confined cattle fed for slaughter to increase weight gain, improve feed efficiency, and decrease the incidence of liver abscesses.
b) Bambermycins - Approved for increased weight gain and improved feed efficiency in confined cattle fed to slaughter and for increased weight gain in pasture cattle.
c) Tylosin - Commonly fed to decrease the incidence of liver abscesses in confined cattle, and approved for combination feeding with monensin.
d) Chlortetracycline (CTC) - Approved for a variety of purposes in various classes of beef cattle; The CTC is generally used to prevent BRD and anaplasmosis and for growth promotion and improvement of feed efficiency.
e) Oxytetracycline - Approved for purposes similar to CTC, and also approved for combination feeding with lasalocid for confined cattle to decrease the incidence of liver abscesses.
e) Decoquinate - A compound approved for feeding to cattle for prevention of coccidiosis in cattle.
f) Melengestrol acetate (MGA) - Used to inhibit estrus in finishing beef heifers, resulting in improved gain and feed efficiency . . . Variable response though!

2) Probiotics - Microbial preparations and growth-media extracts:

a) Used widely in ruminant production - Yeast cultures and live cultures of Lactobacillus acidophilus and Streptococcus faecium are the most common.
b) Microbial cultures have been used primarily for either food preservation, as an aid to restoring gut function, or an agent to enhance feed utilization by ruminants.

NUTRIENT REQUIREMENT TABLES

[Based on NRC, 2000 (Update)]

1. **Table 1. Nutrient Requirements for Growing and Finishing Cattle** (Weight at small marbling, 533 kg; Weight, 200-450 kg; ADG, 0.50-2.50 kg; Breed code, 1 Angus) [NEm = net energy for maintenance; MP = metabolizable protein; ADG = average daily gain]

Body Weight, kg:		200	250	300	350	400	450
Maintenance Requirements:							
NEm	Mcal/d	4.1	4.84	5.55	6.23	6.89	7.52
MP	g/d	202	239	274	307	340	371
Ca	g/d	6	8	9	11	12	14
P	g/d	5	6	7	8	10	11
Growth Requirements (ADG)							
NEg required for gain, Mcal/d							
0.5	kg/d	1.27	1.50	1.72	1.93	2.14	2.33
1.0	kg/d	2.72	3.21	3.68	4.13	4.57	4.99
1.5	kg/d	4.24	5.01	5.74	6.45	7.13	7.79
2.0	kg/d	5.81	6.87	7.88	8.84	9.77	10.68
2.5	kg/d	7.42	8.78	10.06	11.29	12.48	13.64
MP required for gain, g/d							
0.5	kg/d	154	155	158	157	145	133
1.0	kg/d	299	300	303	298	272	246
1.5	kg/d	441	440	442	432	391	352
2.0	kg/d	580	577	577	561	505	451
2.5	kg/d	718	712	710	687	616	547
CalcIum required for gain, g/d							
0.5	kg/d	14	13	12	11	10	9
1.0	kg/d	27	25	23	21	19	17
1.5	kg/d	39	36	33	30	27	25
2.0	kg/d	52	47	43	39	35	32
2.5	kg/d	64	59	53	48	43	38
Phosphoros required for gain, g/d							
0.5	kg/d	6	5	5	4	4	4
1.0	kg/d	11	10	9	8	8	7
1.5	kg/d	16	15	13	12	11	10
2.0	kg/d	21	19	18	16	14	13
2.5	kg/d	26	24	22	19	17	15

2. **Table 2 Nutrient Requirements for Growing Bulls** (Weight at maturity, 890 kg; Weight, 300-800 kg; ADG, 0.50-2.50 kg; Breed code, 1 Angus) [NEm = net energy for maintenance; MP = metabolizable protein; ADG = average daily gain]

Body Weight, kg:		300	400	500	600	700	800
Maintenance Requirements							
NEm	Mcal/day	6.38	7.92	9.36	10.73	12.05	13.32
MP	g/d	274	340	402	461	517	572
Ca	g/d	9	12	15	19	22	25
P	g/d	7	10	12	14	17	19
Growth Requirements (ADG)							
NEg Required for Gain, Mcal/d							
0.5	kg/d	1.72	2.13	2.52	2.89	3.25	3.59
1.0	kg/d	3.68	4.56	5.39	6.18	6.94	7.67
1.5	kg/d	5.74	7.12	8.42	9.65	10.83	11.97
2.0	kg/d	7.87	9.76	11.54	13.23	14.85	16.41
2.5	kg/d	10.05	12.47	14.74	16.90	18.97	20.97
MP Required for Gain, g/d							
0.5	kg/d	158	145	122	100	78	58
1.0	kg/d	303	272	222	175	130	86
1.5	kg/d	442	392	314	241	170	102
2.0	kg/d	577	506	400	299	202	109
2.5	kg/d	710	617	481	352	228	109
Calcium Required for Gain, g/d							
0.5	kg/d	12	10	9	7	6	4
1.0	kg/d	23	19	16	12	9	6
1.5	kg/d	33	27	22	17	12	7
2.0	kg/d	43	35	28	21	14	8
2.5	kg/d	53	43	34	25	16	8
Phosphorus Required for Gain, g/d							
0.5	kg/d	5	4	3	3	2	2
1.0	kg/d	9	8	6	5	4	2
1.5	kg/d	13	11	9	7	5	3
2.0	kg/d	18	14	11	8	6	3
2.5	kg/d	22	17	14	10	6	3

3. **Table 3. Nutrient Requirements of Pregnant Replacement Heifers** (Mature weight, 533 kg; Calf birth weight, 40 kg; Age @ Breeding, 15 months; Breed Code, 1 Angus) [NEm = net energy for maintenance; MP = metabolizable protein; ADG = average daily gain]

	Months Since Conception								
	1	2	3	4	5	6	7	8	9
Requirements									
NEm, Mca1/d									
Maintenance	5.98	6.14	6.30	6.46	6.61	6.77	6.92	7.07	7.23
Growth	2.29	2.36	2.42	2.48	2.54	2.59	2.65	2.71	2.77
Pregnancy	0.03	0.07	0.16	0.32	0.64	1.18	2.08	3.44	5.37
Total	8.31	8.57	8.87	9.26	9.79	10.55	11.65	13.23	15.37
MP, g/d									
Maintenance	295	303	311	319	326	334	342	349	357
Growth	118	119	119	119	119	117	115	113	110
Pregnancy	2	4	7	18	27	50	88	151	251
Tota1	415	425	437	457	472	501	545	613	718
Calcium, g/d									
Maintenance	10	11	11	11	12	12	12	13	13
Growth	9	9	9	8	8	8	8	8	8
Pregnancy	0	0	0	0	0	0	12	12	12
Total	19	19	20	20	20	20	33	33	33
Phosphorus, g/d									
Maintenance	8	8	8	9	9	9	10	10	10
Growth	4	4	3	3	3	3	3	3	3
Pregnancy	0	0	0	0	0	0	7	7	7
Total	12	12	12	12	12	13	20	20	20
Body Weight									
ADG, kg/d									
Growth	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Pregnancy	0.03	0.05	0.08	0.12	0.19	0.28	0.40	0.57	0.77
Tota1	0.42	0.44	0.47	0.51	0.58	0.67	0.79	0.96	l.16
Body weight, kg									
Shrunk body	332	343	355	367	379	391	403	415	426
Gravid uterus mass	1	3	4	7	12	19	29	44	64
Total	333	346	360	375	391	410	432	459	491

4. **Table 4. Nutrient Requirements of Beef Cows** [SNF = solids not fat; NEm = net energy for maintenance; MP = metabolizable protein; ADG = average daily gain]

Mature Weight	533 kg	Milk Fat	4.0 %
Calf Birth Weight	40 kg	Milk Protein	3.4 %
Age @ Calving	60 months	Calving Interval	12 months
Age @ Weaning	30 weeks	Time Peak	8.5 weeks
Peak Milk	8 kg	Milk SNF	8.3 %
Breed Code	1 Angus		

	Month Since Calving											
	1	2	3	4	5	6	7	8	9	10	11	12
NEm Requirement Factor, %:	100	100	100	100	100	100	100	100	100	100	100	100
Requirements												
NEm, Mcal/d												
Maintenance	10.25	10.25	10.25	10.25	10.25	10.25	8.54	8.54	8.54	8.54	8.54	8.54
Growth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lactation	4.78	5.74	5.17	4.13	3.10	2.23	0.00	0.00	0.00	0.00	0.00	0.00
Pregnancy	0.00	0.00	0.01	0.03	0.07	0.16	0.32	0.64	1.18	2.08	3.44	5.37
Total	15.03	15.99	15.43	14.41	13.42	12.64	8.87	9.18	9.72	10.62	11.98	13.91
MP, g/d												
Maintenance	422	422	422	422	422	422	422	422	422	422	422	422
Growth	0	0	0	0	0	0	0	0	0	0	0	0
Lactation	349	418	376	301	226	163	0	0	0	0	0	0
Pregnancy	0	0	1	2	4	7	14	27	50	88	151	251
Total	770	840	799	724	651	591	436	449	471	510	573	672
Calcium, g/d												
Maintenance	16	16	16	16	16	16	16	16	16	16	16	16
Growth	0	0	0	0	0	0	0	0	0	0	0	0
Lactation	16	20	18	14	11	8	0	0	0	0	0	0
Pregnancy	0	0	0	0	0	0	0	0	0	12	12	12
Total	33	36	34	31	27	24	16	16	16	29	29	29
Phosphorus, g/d												
Maintenance	13	13	13	13	13	13	13	13	13	13	13	13
Growth	0	0	0	0	0	0	0	0	0	0	0	0
Lactation	9	11	10	8	6	4	0	0	0	0	0	0
Pregnancy	0	0	0	0	0	0	0	0	0	5	5	5
Total	22	24	23	21	19	17	13	13	13	18	18	18
Body Weight & Milk												
ADG, kg/d												
Growth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pregnancy	0.00	0.00	0.02	0.03	0.05	0.08	0.12	0.19	0.28	0.40	0.57	0.77
Total	0.00	0.00	0.02	0.03	0.05	0.08	0.12	0.19	0.28	0.40	0.57	0.77
Milk kg/d	6.7	8.0	7.2	5.8	4.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0
Body weight, kg												
Shrunk Body	533	533	533	533	533	533	533	533	533	533	533	533
Conceptus	0	0	1	1	3	4	7	12	19	29	44	64
Total	533	533	534	534	536	537	540	545	552	562	577	597

5. **Table 5. Diet Evaluation for Growing and Finishing Cattle** (Weight at small marbling, 533 kg; Breed code, 1 Angus) [eNDF = effective neutral detergent fiber; TDN = total digestible nutrients; NEm = net energy for maintenance; NEg = net energy for gain; CP = crude protein; DIP = degraded intake protein; DMI = dry matter intake; ADG = average daily gain; UIP = undegraded intake protein; MP = metabolizable protein]

Ration	eNDF % DM	TDN % DM	NEm Mcal/kg	NEg Mcal/kg	CP % DM	DIP % CP	Weight Class	NE Adjuster, %
A	57	50	1.00	0.45	7.4	88	325	100
B	43	60	1.35	0.77	10.0	78	350	100
C	30	70	1.67	1.06	12.6	72.4	375	100
D	5	80	1.99	1.33	14.4	48.5	400	100
E	3	90	2.29	1.59	16.6	44.2	425	100

Body weight, kg/ Ration		DMI Adjuster, %	DMI, kg/d	ADG, kg/d	Balances, g/d			Requirement, % of DM	
					DIP	UIP	MP	Ca	P
300	A	100	7.9	0.32	1	0	0	0.22	0.13
	B	100	8.4	0.89	0	0	0	0.35	0.18
	C	100	8.2	1.36	2	0	0	0.48	0.24
	D	100	7.7	1.69	1	2	1	0.60	0.29
	E	100	7.1	1.90	1	2	1	0.71	0.34
325	A	100	8.4	0.32	1	14	11	0.21	0.13
	B	100	8.9	0.89	0	38	30	0.33	0.18
	C	100	8.7	1.36	2	57	46	0.45	0.22
	D	100	8.2	1.69	1	73	58	0.55	0.27
	E	100	7.6	1.90	1	82	66	0.65	0.31
350	A	100	8.9	0.32	1	27	22	0.20	0.13
	B	100	9.4	0.89	0	75	60	0.31	0.17
	C	100	9.2	1.36	2	114	91	0.42	0.21
	D	100	8.7	1.69	1	143	114	0.51	0.25
	E	100	8.0	1.90	1	160	128	0.60	0.29
375	A	100	9.4	0.32	1	40	32	0.20	0.13
	B	100	9.9	0.89	0	111	89	0.30	0.16
	C	100	9.7	1.36	2	169	135	0.39	0.20
	D	100	9.1	1.69	1	212	169	0.48	0.24
	E	100	8.4	1.90	1	238	190	0.56	0.28
400	A	100	9.8	0.32	1	53	43	0.19	0.12
	B	100	10.4	0.89	0	147	118	0.28	0.16
	C	100	10.2	1.36	2	223	178	0.37	0.19
	D	100	9.6	1.69	2	279	223	0.44	0.23
	E	100	8.8	1.90	1	314	251	0.52	0.26
425	A	100	10.3	0.32	1	66	53	0.19	0.12
	B	100	10.9	0.89	0	182	146	0.27	0.15
	C	100	10.6	1.36	2	276	221	0.35	0.19
	D	100	10.0	1.69	2	346	277	0.42	0.22
	E	100	9.3	1.90	1	388	311	0.48	0.25

6. **Table 6. Diet Eva1uation for Growing Bulls** (Weight at maturity, 890 kg; Breed code, 1 Angus) [eNDF = effective neutral detergent fiber; TDN = total digestible nutrients; NEm = net energy for maintenance; NEg = net energy for gain; CP = crude protein; DIP = degraded intake protein; DMI = dry matter intake; ADG = average daily gain; UIP = undegraded intake protein; MP = metabolizable protein]

Ration	eNDF % DM	TDN % DM	NEm Mcal/kg	NEg Mcal/kg	CP % DM	DIP % CP	Weight Class	NE Adjuster, %
A	43	50	1.00	0.45	8.2	80	325	100
B	37	65	1.51	0.92	10.9	78	350	100
C	30	70	1.67	1.06	12.0	76	375	100
D	20	75	1.83	1.20	13.4	73	400	100
E	5	80	1.99	1.33	13.8	51	425	100

Body weight, kg/ Ration		DMI Adjuster, %	DMI, kg/d	ADG, kg/d	Balances, g/d			Requirement, % of DM	
					DIP	UIP	MP	Ca	P
300	A	100	7.9	0.22	5	103	83	0.18	0.12
	B	100	8.3	1.02	4	8	6	0.39	0.20
	C	100	8.2	1.23	2	-3	-2	0.45	0.23
	D	100	8.0	1.41	3	10	8	0.51	0.25
	E	100	7.7	1.56	5	-2	-2	0.56	0.27
325	A	100	8.4	0.22	5	119	95	0.18	0.12
	B	100	8.8	1.02	5	51	41	0.36	0.19
	C	100	8.7	1.23	2	49	39	0.42	0.21
	D	100	8.5	1.41	3	70	56	0.47	0.24
	E	100	8.2	1.56	6	63	51	0.52	0.26
350	A	100	8.9	0.22	5	134	107	0.18	0.12
	B	100	9.4	1.02	5	94	75	0.34	0.18
	C	100	9.2	1.23	2	100	80	0.39	0.20
	D	100	9.0	1.41	3	129	103	0.44	0.22
	E	100	8.7	1.56	6	128	102	0.48	0.24
375	A	100	9.4	0.22	6	149	119	0.18	0.12
	B	100	9.8	1.02	5	136	109	0.32	0.17
	C	100	9.7	1.23	2	150	125	0.37	0.19
	D	100	9.4	1.41	3	187	149	0.41	0.21
	E	100	9.1	1.56	6	191	153	0.45	0.23
400	A	100	9.8	0.22	6	161	131	0.17	0.12
	B	100	10.3	1.02	5	177	142	0.31	0.17
	C	100	10.2	1.23	2	199	159	0.35	0.19
	D	100	9.9	1.41	3	244	195	0.39	0.20
	E	100	9.6	1.56	7	253	202	0.42	0.22
425	A.	100	10.3	0.22	6	169	143	0.17	0.12
	B	100	10.8	1.02	6	218	174	0.29	0.16
	C	100	10.6	1.23	2	247	198	0.33	0.18
	D	100	10.4	1.41	3	300	240	0.36	0.19
	E	100	10.0	1.56	7	314	251	0.40	0.21

7. **Table 7. Diet Evaluation for Pregnant Replacement Heifers** (Mature weight, 533 kg; Calf birth weight, 40 kg; Age @ breeding, 15 months; Breed Code, 1 Angus) [TDN = total digestible nutrients; NEm = net energy for maintenance; NEg = net energy for gain; CP = crude protein; DIP = degraded intake protein; DMI = dry matter intake; ADG = average daily gain; UIP = undegraded intake protein; MP = metabolizable protein]

Ration	TDN, % DM	NEm, Mcal/kg	NEg, Mcal/kg	CP, % DM	DIP, % DM	DMI Factor, %
A	50	1.00	0.45	8.2	80	100
B	60	1.35	0.77	9.8	80	100
C	70	1.67	1.06	11.4	80	100

		Months Since Conception								
		1	2	3	4	5	6	7	8	9
NEm Requirement Factor, %:		100	100	100	100	100	100	100	100	100
Ration										
A	DM, kg	8.5	8.8	9.0	9.2	9.4	9.7	9.9	10.1	10.3
	NE allowed ADG	0.35	0.34	0.33	0.31	0.28	0.22	0.12	0.00	0.00
	DIP Balance, g/d	5	5	5	6	6	6	6	6	6
	UIP Balance, g/d	75	79	83	87	90	92	90	66	-53
	MP Balance, g/d	60	63	67	69	72	74	72	52	-42
	Ca, % DM	0.22	0.21	0.21	0.20	0.19	0.18	0.28	0.25	0.25
	P, % DM	0.17	0.17	0.16	0.16	0.15	0.14	0.19	0.16	0.16
B	DM, kg	9.0	9.3	9.5	9.7	10.0	10.2	10.4	10.7	10.9
	NE allowed ADG	0.96	0.96	0.95	0.92	0.88	0.82	0.71	0.54	0.30
	DIP Balance, g/d	4	4	4	4	4	4	4	4	4
	UIP Balance, g/d	5	14	22	30	38	49	54	46	18
	MP Balance, g/d	4	11	18	24	31	40	43	37	14
	Ca, % DM	0.36	0.35	0.33	0.32	0.31	0.29	0.38	0.34	0.29
	P, % DM	0.27	0.27	0.26	0.26	0.25	0.23	0.27	0.24	0.20
C	DM, kg	8.8	9.1	9.3	9.5	9.8	10.0	10.2	10.4	10.7
	NE allowed ADG	1.47	1.46	1.45	1.42	1.38	1.31	1.19	1.02	0.77
	DIP Balance, g/d	2	2	2	2	2	2	2	2	2
	UIP Balance, g/d	-66	-54	-43	-32	-19	-1	10	8	-18
	MP Balance, g/d	-53	-43	-34	-26	-15	-1	8	6	-14
	Ca, % DM	0.48	0.47	0.45	0.43	0.41	0.39	0.48	0.43	0.38
	P, % DM	0.37	0.36	0.35	0.35	0.33	0.31	0.35	0.32	0.28

☞NOTE: Requirements are for NE allowed ADG and target weight. NE allowed ADG is ADG independent of conceptus gain.

8. Table 8. Diet Evaluation for Beef Cows [TDN = total digestible nutrients; ME = metabolizable energy; NEm = net energy for maintenance; CP = crude protein; DIP = degraded intake protein; DMI = dry matter intake; UIP = undegraded intake protein; MP = metabolizable protein]

Mature Weight	533 kg	Milk Fat	4.0 %
Calf Birth Weight	40 kg	Milk Protein	3.4 %
Age @ Calving	60 months	Calving Interval	12 months
Age @ Weaning	30 weeks	Time Peak	8.5 weeks
Peak Milk	8 kg	Milk SNF	8.3 %
Breed Code	1 Angus		

Ration	TDN, % DM	ME, Mcal/kg	NEm, Mcal/kg	CP, % DM	DIP, % CP	DMI Factor, %
A	50	1.84	1.00	7.9	82.5	100
B	60	2.21	1.35	7.8	100.0	100
C	70	2.58	1.67	9.1	100.0	100

		Months Since Calving											
		1	2	3	4	5	6	7	8	9	10	11	12
	NEm Requirement Factor, %:	100	100	100	100	100	100	100	100	100	100	100	100
	Milk kg/d:	6.7	8.0	7.2	5.8	4.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0
A	DM, kg	11.14	11.40	12.12	11.83	11.54	11.30	10.68	10.68	10.68	10.68	10.68	10.68
	Energy Balance, Mcal/d	-3.00	-4.59	-3.31	-2.58	-1.88	-1.34	1.81	1.50	0.95	0.06	-1.30	-3.24
	DIP Balance, g/d	7	7	7	7	7	7	6	6	6	6	6	6
	UIP Balance, g/d	-201	-270	-169	-96	-24	34	175	170	142	93	14	-110
	MP Balance, g/d	-161	-216	-136	-77	-19	27	149	136	113	75	11	-88
	Ca, % DM	0.65	0.70	0.62	0.57	0.52	0.47	0.34	0.34	0.34	0.59	0.59	0.59
	P, % DM	0.20	0.21	0.19	0.18	0.16	0.15	0.12	0.12	0.12	0.17	0.17	0.17
	Reserves Flux/mo, Mcal	-148	-174	-126	-98	-71	-51	55	46	29	2	-50	-123
B	DM, kg	11.96	12.23	12.72	12.43	12.14	11.00	11.28	11.28	11.28	11.28	11.28	11.28
	Energy Balance, Mcal	1.07	0.47	1.69	2.32	2.92	3.38	6.32	6.00	5.46	4.56	3.20	1.27
	DIP Balance, g/d	5	5	5	5	5	5	5	5	5	5	5	5
	UIP Balance, g/d	18	-47	44	114	182	233	221	221	221	221	209	85
	MP Balance, g/d	14	-38	35	91	146	189	304	291	269	230	167	68
	Ca, % DM	0.27	0.30	0.27	0.25	0.22	0.20	0	.15	0.15	0.15	0.25	0.25	0.25
	P, % DM	0.19	0.20	0.18	0.17	0.16	0.14	0.11	0.11	0.11	0.16	0.16	0.16
	Reserves Flux/mo, Mcal	32	14	51	71	89	103	192	183	166	139	97	39
C	DM, kg	13.16	13.42	13.79	13.50	13.21	12.97	12.35	12.35	12.35	12.35	12.35	12.35
	Energy Balance, Mcal/d	6.99	6.48	7.65	8.18	8.69	9.07	11.80	11.49	10.95	10.05	8.69	6.76
	DIP Balance, g/d	3	3	3	3	3	3	2	2	2	2	2	2
	UIP Balance, g/d	295	233	314	308	301	296	282	282	282	282	282	282
	MP Balance, g/d	236	187	256	308	360	401	509	496	473	435	371	272
	Ca, % DM	0.25	0.27	0.25	0.23	0.20	0.19	0.13	0.13	0.13	0.23	0.23	0.23
	P, % DM	0.17	0.18	0.17	0.15	0.14	0.13	0.10	0.10	0.10	0.14	0.14	0.14
	Reserves Flux/mo, Mcal	212	197	233	249	264	276	359	349	333	306	264	205