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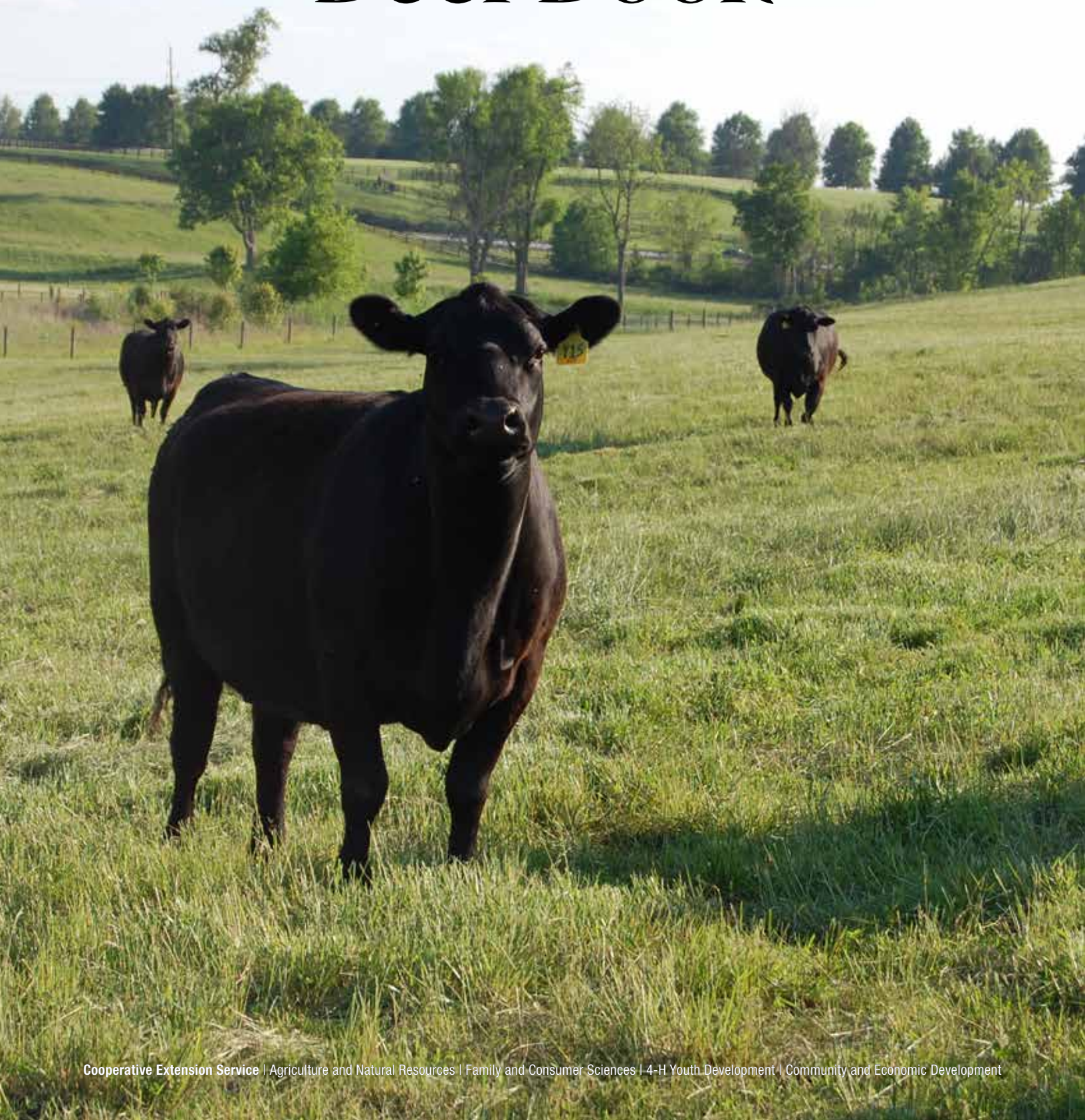
University of Kentucky
College of Agriculture,
Food and Environment
Cooperative Extension Service

The Kentucky Beef Book



The Kentucky Beef Book

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Contents

Introduction

Les Anderson and Roy Burris

Our Beef Cattle History

Kentucky has a rich agricultural history, and beef cattle have been a major part of that history for more than two centuries. In the early 1780s, settlers who poured across the Appalachian Mountains brought cattle with them. These early cattle, which were also used for milk and draft, were mostly "mongrels," predominantly of Devon ("Rubies") or Spanish blood. As early as 1784, cattle also were being driven from the south branch of the Potomac to the glades of what is now Kentucky for summer pasture.

Many of the early cattle were kept near cabins and ate "switch cane," which grew wild among large trees. However, in 1792, Kentuckian Thomas Goff, on a trip to Virginia, saw his horse eating a strange grass (bluegrass) in the Powell Valley, and he brought some seed back to Kentucky. Bluegrass, along with corn, later became the base of the cattle-feeding program. Cattlemen wintered their two-year-old steers on shocked corn, put them on bluegrass in the spring and summer, then fed them corn until February when the drive to market began. Cattle were driven to markets in the East, generally at the speed of about seven miles a day.

In 1785, a family named Patton migrated to Kentucky (near Winchester) and brought a bull exported from England and some grade heifers. Later they brought into Kentucky a "full-blooded" (possibly Shorthorn) bull and cow—Mars and Venus. Through several years of selective breeding, they developed the "Patton Stock," which became the foundation of some early Kentucky breeding stock.

Shorthorn cattle were first imported into Virginia in 1783, and purebred Shorthorn cattle soon appeared in Kentucky. Their popularity increased rapidly, and Kentucky breeders established the Shorthorn herd book and record association—the first in the United States.

Famous statesman and politician Henry Clay is credited with bringing the first Herefords to Kentucky in 1817. However, their popularity did not increase like the Shorthorns. That same year, Lewis Sanders of Bourbon County imported four pairs of Shorthorns, one pair of Longhorns, and one pair of Herefords. These Shorthorn cattle, which had numerous descendants, became known as the "seventeens" in reference to the year 1817.

By 1837, the Shorthorns were immensely popular. Many producers feared they would become inbred and fail to pass on desirable traits. They were crossed with other breeds, especially Longhorns from the South. Longhorns were later discriminated against by packers, causing a good deal of panic among Kentucky producers who had crossed their cattle with Longhorns.

About 1888, the Shorthorn business collapsed to a great degree, and Herefords swept to popularity, not necessarily because of superior hardiness but because Shorthorn breeders had been selling pedigrees instead of individuals.

As early as 1840, Kentuckians were aware of the state's potential to produce forage. Cattlemen in the Barrens (between the Green and Cumberland rivers) stated, "Grass can be the only basis for our cattle industry. We can never be a stock-raising country to any extent until we change our system of farming. We must grass our lands and plow less."

By the 1850s, a system of marketing that centered on "court day" had evolved in Kentucky. Each county court usually held session one day a month at the county seat. Kentuckians came to town to conduct legal business, buy supplies, and sell their products, including cattle. Cattle were moved into town, along with farm equipment, to be traded on or auctioned off. One of the best known court days occurred in Paris, where as much as $250,000 worth of cattle, horses, and mules changed hands in a single day.

Cattle numbers steadily increased in Kentucky's Bluegrass area. Bourbon, Clark, Madison, Fayette, and Shelby counties each had 10,000 to 12,000 head of cattle during the 1840s and 1850s.

Table 1-1. Kentucky cattle inventory for selected years (1,000 head).

Year	Beef Cows	Milk Cows	Steers[1]
1920	65	455	161
1930	45	498	98
1940	80	555	140
1950	187	661	149
1960	515	561	197
1970	1,055[2]	279	230
1980	1,106	244	221
1990	1,040	210	180
2000	1,070	135	180
2010	1,070	80	235
2017	1,023	57	210

[1] Refers to steers over one year of age or, in later years, steers over 500 pounds.
[2] Beef cow numbers peaked in 1975 at 1,429,000.

The first comprehensive cattle inventory was taken in Kentucky in 1920 (see Table 1-1). At that time, there were only 65,000 beef cows in the state, but there were 161,000 steers over one year old and 197,000 other calves (not kept for milk). The 1942 inventory recorded the first big increase in beef cows (105,000 head), while steers over one year old had decreased since 1920.

It is likely no coincidence that the buildup of beef cow numbers in the 1940s occurred along with the introduction of Kentucky 31 tall fescue. This new grass grew anywhere, prevented erosion, and could be used to support the growing cow herd.

As Kentucky moved into a grassland system of cattle production, emphasis changed from the grazing and feeding of mature steers to a cow-calf system of production. Corn Belt cattle feeders turned to the South as a major supplier of feeder cattle. Kentucky, Tennessee, and Virginia provided the largest numbers of these calves.

During the 1950s, the production of feeder calves increased as farmers realized beef cow herds made efficient use of available pasture land. However, many nondescript cows scattered across the state were not yielding quality feeder

calves. Dr. W. P. Garrigus of the University of Kentucky introduced the Kentucky Cow-Calf Plan, which suggested the use of these cows to produce baby beef. This widely adopted program emphasized the use of quality beef bulls and led to the upgrading of beef cattle from many "family milk cows." Kentucky beef cow numbers doubled in the 1950s and again in the 1960s. On January 1, 1970, the beef cow population numbered more than 1 million head. This increase in beef cow numbers was perhaps the most dynamic development in Kentucky agriculture during that period.

The physical appearance of beef cattle also has changed over time. Early British cattle, which were used mainly for draft and milk, were large-framed, late-maturing, and not "finished" until they were three or four years old. Producers attempted to reduce size and hasten maturity and ability to fatten earlier. This trend intensified from the mid-1930s to the mid-1950s, as smaller, earlier-maturing, and earlier-fattening cattle were selectively bred. By the late 1950s, this practice had been taken to extreme, and breeding stock were excessively small and fat.

In the mid-1960s, the beef cattle industry began to move toward cattle that could be grown to desirable slaughter weights without becoming too fat. The feedlot performance of Charolais crossbred steers in the 1960s created an awareness of the lean growth potential of the European breeds of cattle. In the late 1960s, breeders began selecting within their breeds for larger-framed, growthier, and leaner cattle. The use of other European breeds also increased at that time.

This intense selection for large-framed, lean cattle was also taken to extreme and caused concern because of carcass size, carcass grade, maintenance cost, and efficiency of resource utilization. Presently, selection emphasis is toward lean cattle of moderate frame with easy fleshing ability. Kentucky survived the "market crash" in 1974, and in recent years Kentucky has shown the largest increase in beef cow numbers in the United States, while other states generally have declined.

Today's Kentucky Beef Industry

Kentucky presently has the twelfth largest cattle herd in the United States at 2.16 million head as of January 2017. Kentucky's beef cow herd is the eighth largest in the United States (the largest east of the Mississippi River) with 1.089 million beef cows. According to recent data, beef cows are on 38,000 of Kentucky's 76,000 farms. The average herd size for beef cattle farms in Kentucky is 27 head. The economic impact of the production from these operations is significant. Sales of cattle and calves generated $1.034 billion in cash receipts to Kentucky's farmers during 2017, accounting for 12.4% of total farm cash receipts.

Kentucky beef producers generally have two important reasons for raising beef cattle on their farms:

- The availability of land or roughage resources
- Beef cattle requirements for less labor than other livestock enterprises (making the cow-calf enterprise complementary to off-farm employment)

Enjoyment in raising cattle may also be an important reason. The typical Kentucky beef herd has about 27 cows (86% of all herds have fewer than 50 cows) and one bull, uses land not suitable for row crops, may be characterized as a "loosely managed operation," and may have no defined calving season. Practices known to improve beef productivity and efficiency have only recently begun to be widely adopted by Kentucky farmers.

Kentucky is ideally suited for cattle production. The main feed for cattle is a renewable resource Kentucky has in abundance—forages. The majority of the state's terrain favors cattle production over row crops. Kentucky farms cover 14 million acres, with approximately half of that occupied by forage grasses and legumes. Our natural resources and climate permit the growth of most cool-season and warm-season species. Water is readily available in all areas of the state, and we have a relatively long growing season.

A major percentage (83%) of the feed units for beef cattle comes from forages, and livestock and livestock products account for 51% of Kentucky's agricultural cash receipts. Cash hay also accounts for 24% of the total crop value in the state. In addition, forages play a major role in soil conservation, seed production, and aesthetics.

Environmental Stewardship and the Cattle Industry

The main challenges farmers may face today include the need to produce quality food on a limited amount of land; the demand for a consistent, safe, and cheap product by consumers; and increasing public awareness related to the use of environmentally and economically sustainable methods for food production. These challenges usually involve adoption of technology and practices such as the sensible use of pesticides and animal medications; implementation of sound soil, water, and nutrient management strategies; responsible use of new technologies; and appreciation for the health and well-being of animals.

The world is probably better fed today than ever due to major technological and scientific advancements in agriculture. In fact, the use of new equipment and technology together with innovative management practices in the last 20 or 30 years has changed the way food is produced. As a result, concerns about the effects of agricultural chemicals, livestock manure, and biotechnology on the environment need to be addressed. Other concerns include depletion and degradation of resources such as water and soil. The effect of large-scale agriculture on the environment and on wildlife and wildlife habitat and its potential contribution to global warming are also issues of debate. Everyone is concerned with protecting the environment. Both rural and urban citizens are concerned about the impact of livestock and agriculture on their water, their health, and their quality of life.

Both federal and state governments have invested large amounts of money in recent years not only to research but also to promote and enhance sustainable agricultural practices. Most of these programs help farmers address issues such as soil conservation, erosion control, water quality, improved pesticide use, and improved manure handling, storage, and land application.

Large concentrations of animals in confined areas, such as wintering feeding sites or barns and feedlots, increase the potential problems related to the recycling of animal manure to improve soil fertility. Manure and other fertilizers help enrich the soil and most of the time make good ecological sense, but too much can cause environmental problems, such as pollution of both ground and surface waters. Increasingly, farmers are using tools such as Nutrient Management Planning (NMP) to help ensure that nutrients contained in both manure and commercial fertilizers are stored safely and applied to the land in the right amounts, using the proper methods and at the right times of the growing season. Such plans are becoming mandatory in some areas, together with other standards in manure management. In addition to nutrient management, a good steward of the land and environment should adopt several strategies to minimize water quality impact, especially where cattle have free access to surface water. Many producers currently manage their cow-calf operation using rotational grazing, alternative water supply, limited stream access, and geotextile and gravel pads to minimize mud issues in heavy traffic areas. The use of such practices significantly helps reduce environmental impacts and displays good stewardship of shared resources. Other benefits include increased productivity, improved working and living environment, sustainability of the business, and potential value-added marketing.

Meeting Our Potential

Kentucky's forage base consists of cool-season grasses and legumes. Four grasses compose the vast majority of our forage land, with Kentucky 31 tall fescue occupying the largest number of acres (Figure 1-1). Red, ladino, and white clovers (Figure 1-2) are by far the dominant legumes found in Kentucky's hay and pasture fields.

Two components of Kentucky's beef industry most likely to have the greatest impact on the industry meeting its potential are increasing numbers and adding value to current production. Kentucky's forage base can support a large number of cattle. As a renewable resource, forage can only be utilized by ruminant animals like cattle to bring an economic return to the state. However, this resource requires better and more efficient management to support potential beef numbers. If managed properly, Kentucky's forage can produce feeder cattle more economically than that of other states, giving Kentucky producers an opportunity to replace diminishing tobacco revenue. The latest management techniques and practices to accomplish this task are discussed at length in this reference book.

Figure 1-1. Four grasses compose the majority of Kentucky's forage land. Kentucky 31 tall fescue occupies the largest number of acres.

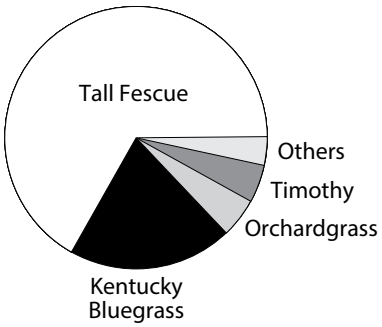
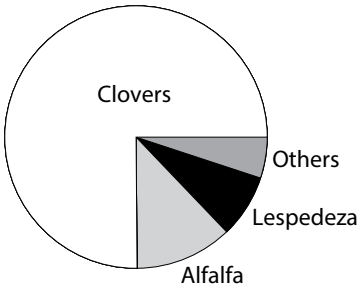


Figure 1-2. Red, ladino, and white clovers are the dominant legumes found in Kentucky's hay and pasture fields.



Adding value to Kentucky beef calves can be accomplished in several ways. Increasing weaning weights, producing uniform calves of similar weights, improving marketing methods and information, and producing consumer-acceptable calves can all add value to Kentucky's calves before they leave the farm. Each of these topics is discussed in detail in later chapters of this book.

UK Beef Educational Programs and The Kentucky Beef Book

Cattlemen in Kentucky have an opportunity to participate in the most rigorous educational programming in the United States. These programs include Master Cattleman, Master Stocker, Master Grazer, Master Marketer, Applied Master Cattleman, Cow College, Beef Quality Assurance, Cattle Handling and Care, Pasture to Plate, and the Integrated Reproductive Management Program. These educational programs are developed and delivered by the Beef Extension Specialists at the University of Kentucky in partnership with the Kentucky Beef Network and funded by the Agriculture Development Board and the Governor's Office of Agriculture Policy. This reference book was written by specialists in beef nutrition, beef cattle breeding, beef reproduction, forages, veterinary science, and production economics. The goal is to use this book as to supplement our educational programs and to help Kentucky's beef producers realize greater profits from their beef enterprise regardless of the size of the operation or the expertise of the producer.

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Forages for Beef Cattle

Jimmy C. Henning, Ray Smith, and Chris Teutsch

Forages in the form of pasture, hay and silage/haylage comprise almost all of the diet of beef cattle in Kentucky. Pasture and hayland total almost 6 million acres in Kentucky according to the USDA Agriculture Census of 2017 (Figure 2-1). Although the acreage is more concentrated in the central part of the state, forages are important in each of Kentucky's 120 counties.

The soil and climate in Kentucky supports the production of many different forages. Pastures and hayfields are primarily a mix of cool season perennial grasses and clovers. With good management, pasture can provide 300 days of grazing or more.

Developing a good forage system for beef cattle in Kentucky requires a holistic understanding of the land and forage resource, managing tall fescue and its toxic endophyte, focusing on forage quality, and learning how to efficiently harvest forage as pasture and hay.

Soils in Kentucky are variable, but in general are very productive for growing forage. The soil type and slope of the land will predict the productivity of pastures and hayfields. Producers can assess pasture and hayfield productivity by analyzing their acreage using the online tool of the Natural Resources Conservation Service (NRCS) called the Web Soil Survey (WSS) (Figure 2-2). The WSS will identify the soil types present on a given farm and their ability to produce forage for livestock, known as the carrying capacity. Carrying capacity refers to how many animals a farm or pasture can carry throughout the year without negative environmental impacts. The WSS reports carrying capacity as animal unit months (AUM), which is defined as the amount of forage needed for a 1,000 pound cow for a month. The WSS provides estimates of forage productivity for the land resource—the ability of the soil to produce forage for livestock. Proper pasture management is essential to reach production levels predicted by the WSS. Step-by-step information on using this online tool can be found in UK publication AGR-222: *Estimating Carrying Capacity of Cool-Season Pastures in Kentucky using Web Soil Survey*.

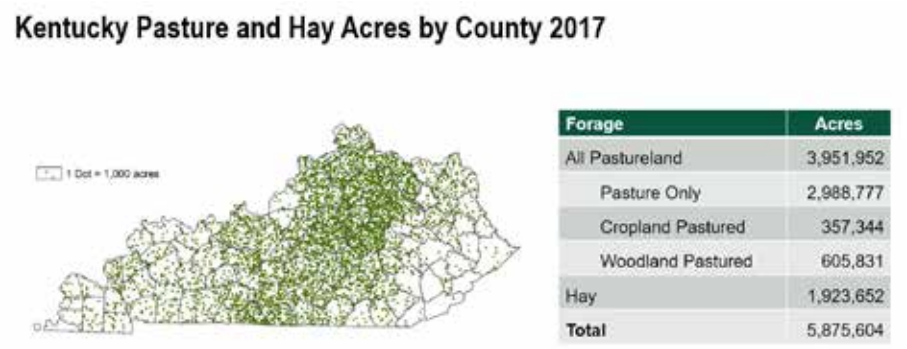

Figure 2-1. Pasture and haylage acreage in Kentucky. Source: USDA 2017 Agriculture Census

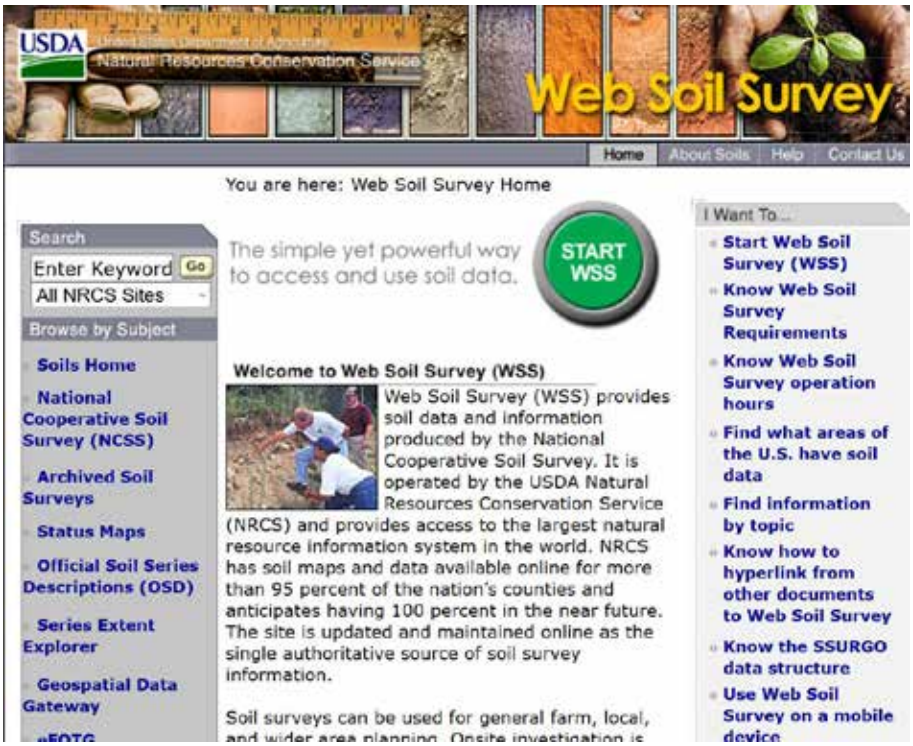

Figure 2-2. The Web Soil Survey (WSS) is an online tool of the USDA-NRCS that provides information on the soil types and productivities on a farm.

Soil Fertility and Forage Productivity

Pasture and hayfields require nutrients to reach peak productivity. These nutrients can be supplied from several sources including residual nutrients in the soil, the breakdown of manure and soil organic matter, nitrogen (N) produced by N-fixation in legumes and commercial fertilizer.

Soil testing is the only way to know what nutrients are available in the soil and what nutrients should be applied to support forage production (Figure 2-3). Producers should take soil samples once per year from hayfields and every two to three years from their pastures. Hayfields need to be checked more frequently since large amounts of nutrients are removed in hay.

Although phosphorus (P), potassium (K), and lime can be added anytime, N fertilizer should be applied when pastures or hayfields are actively growing. Nitrogen is the most limiting nutrient in forage production, especially with predominantly grass stands.

The best management practice to improve N levels in pastures is to interseed legumes (Figure 2-4). Legumes, such as red and ladino white clovers, have the ability to fix N from the air and convert it into a mineral form usable by plants. This is an excellent way to economically increase production of grass pastures.

In several situations, application of N fertilizer is required for optimal yields. Adding N when grass pastures begin to green up in early spring usually provides grazing seven to 12 days earlier than non-fertilized grass. Adding N to tall fescue or Kentucky bluegrass in mid-August (stockpiling) and accumulating fall-grown pasture for late-fall/early-winter grazing can extend the grazing season and reduce the amount of stored feed required. For more information on accumulating tall fescue in the fall see AGR-162: *Stockpiling for Fall and Winter Pasture*. Applying N to pure stands of annual and perennial warm-season grasses will increase growth during the summer months.

Urea (46-0-0) is the most commonly available form of N used by forage producers. Urea is generally safe to handle, easy to store, and the high analysis of N reduces handling, storage, and transport costs in comparison to some other forms of N fertilizer. However, urea is more subject to volatilization losses than other sources of N like ammonium nitrate or ammonium sulfate. Volatilization is more severe when urea is spread on moderate to heavy residues. Also, losses increase when applied at temperatures greater than 75° or on soils with a pH greater than 6.5. It is suggested that urea be applied in cooler temperatures. Apply urea when rain is expected shortly after application if possible. The use of a urease inhibitor can decrease loss potential and reduces volatilization losses by about 15 percent.

Figure 2-3. Make fertilizer applications according to a current soil test.

Table 2-1. Approximate pounds of nutrients removed by various forage crops at specified dry matter yield levels when harvested as hay[1].

	Species and assumed hay yield, tons/A			
	Alfalfa 5	**Tall Fescue 3.5**	**Sorghum-Sudan 4**	**Orchardgrass 4**
Nitrogen	255	130	120	108
Phosphate (P_2O_5)	60	42	38	39
Potassium (K_2O)	245	189	136	162
Magnesium	27	13	27	13
Sulfur	27	20	23	17

[1] Used with permission from 2017 Forage Crop Pocket Guide, 14th Edition, page 22.

Figure 2-4. Legume addition is the most cost effective way to add nitrogen to a pasture or hay system.

Nutrient Removal by Hay and Pasture

Forage crops harvested as hay remove large amounts of nutrients (Table 2-1). Fertilizer needs can be estimated from nutrient removal. Note that unlike most of the common blended fertilizers (e.g. 19-19-19 - 'triple 19'), hay removes about three to four times as much K as P. Maintaining good production on hayfields will require the replacement of these nutrients. In a well-managed pasture system, only a small fraction of the soil N, P, and K is removed by livestock. More than 80 percent of the nutrients in pasture return to the soil in the form of manure and urine. Rotationally grazed pasture will have better nutrient distribution than continuously stocked fields.

Whenever possible, base fertilization programs on a current soil test. Fertilizing according to soil test is more cost effective as it takes into account current nutrient levels in the soil, limiting the over and under application of fertilizer.

For more information on fertilizer applications for pastures and hayfields, see AGR-1: *2020-2021 Lime and Nutrient Recommendations* (http://www.ca.uky.edu/agc/pubs/agr/agr1/AGR1.PDF).

Kentucky's Forage Base

Kentucky's forage base is composed primarily of perennial cool-season grasses and legumes. Tall fescue, orchardgrass, Kentucky bluegrass, and timothy occupy the majority of the forage acres in the state, with tall fescue occupying the largest number of acres (Figure 2-5). Clovers (red, ladino, white) are by far the dominant legumes found in Kentucky hay/pasture fields (Figure 2-6). Alfalfa is the highest yielding, highest quality legume in Kentucky, and is grown primarily for hay. Alfalfa can be part of a well-managed grazing system. Alfalfa is usually grown with a companion grass such as orchardgrass.

Cool-season grasses produce most of their forage in spring and fall (Figure 2-7). In contrast, warm-season grasses are extremely productive during the summer months. Warm season annual grasses include crabgrass, teff, sudangrass, sorghum-sudangrass, and pearl millet. Warm-season perennial grasses adapted to Kentucky include bermudagrass and the native grasses eastern gamagrass, switchgrass, big and little bluestem, and indiangrass. Cool-season annuals such as annual ryegrass, wheat, rye, oats, and barley can be helpful in extending the grazing season in the fall and early spring.

High temperatures and short-term drought stress in summer limit growth of cool season grasses. Warm-season annual grasses can fill this gap with relatively high-quality forage when properly managed (Figure 2-8). A productive forage system in Kentucky will often require a mix of cool- and warm-season annuals and perennial grasses complemented with legumes. The seasonal growth of the most common Kentucky forages is found in Figure 2-9. In addition, the University of Kentucky has one of the most extensive variety testing programs in the country. Go the UK Forages website (https://forages.ca.uky.edu) to access the most current variety reports.

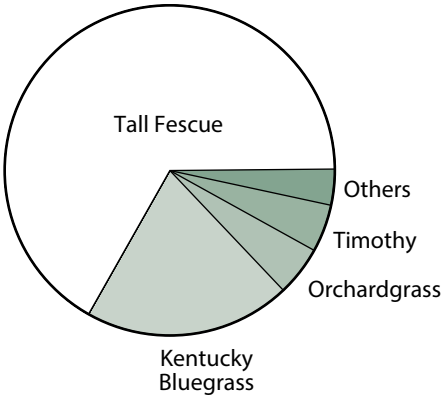

Figure 2-5. Kentucky's grass base.

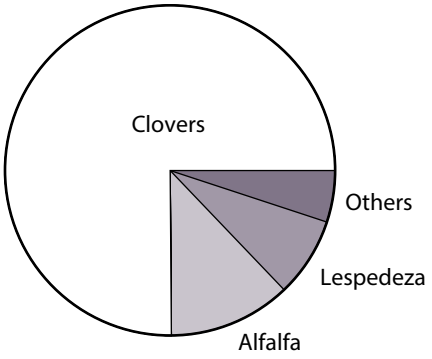

Figure 2-6. Kentucky's legume base.

Common Forage Legumes

White clover (*Trifolium repens*) is a perennial legume that spreads by aboveground horizontal rooting stems called "stolons" (Figure 2-10). White clover produces most of its growth in the spring and fall and is high in quality, but lower in yield than red clover and alfalfa. Because of its spreading nature and reseeding, white clover lasts longer without reseeding than alfalfa and red clover. When white clover

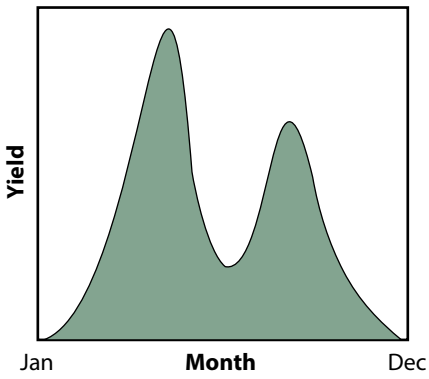

Figure 2-7. Seasonal growth of cool-season pastures.

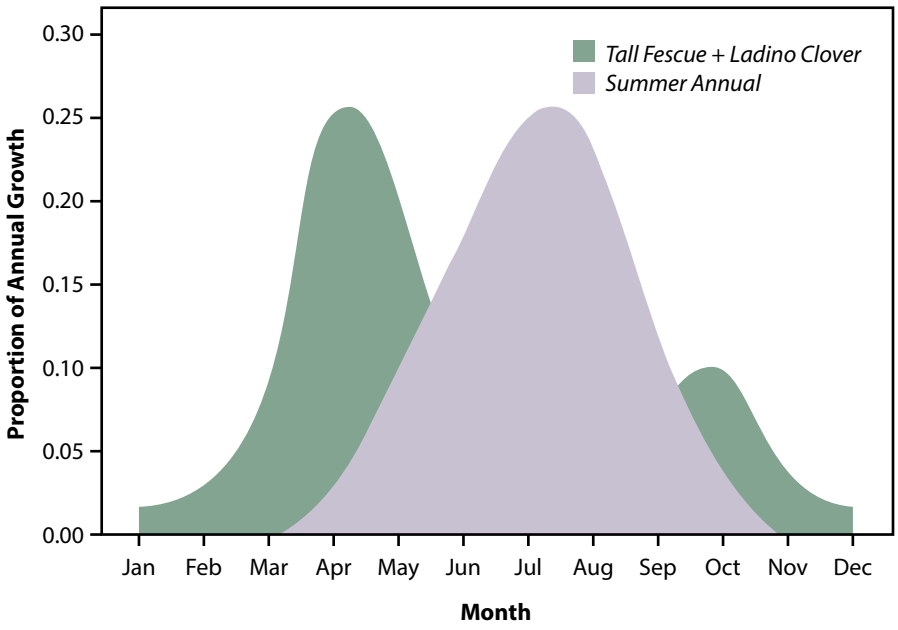

Figure 2-8. Relative monthly production of tall fescue plus clover versus a typical summer annual grass. Summer annual grasses are more productive than cool-season species such as tall fescue and clover in June, July, and August.

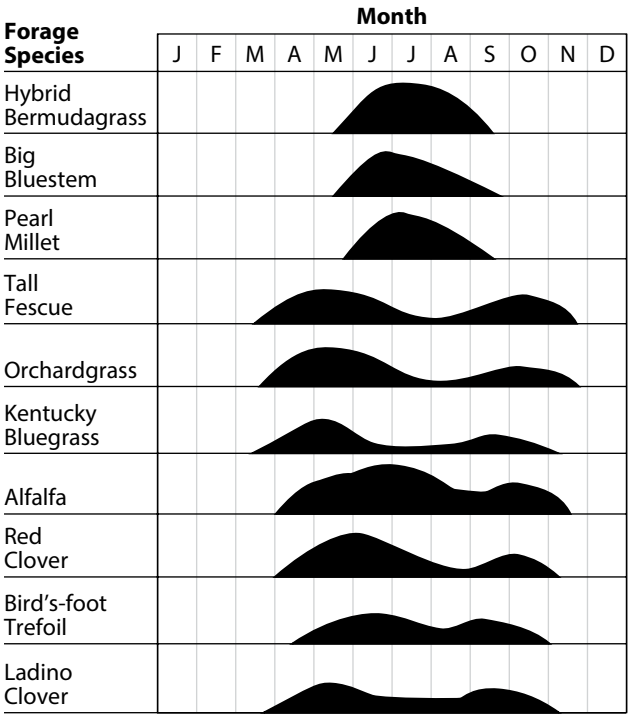

Figure 2-9. Normal forage availability by month.

exceeds 40 percent to 50 percent of the sward, it can cause bloat. The risk is highest when it is grazed during cool, rainy weather when growth is lush. Ladino or intermediate-type white clover varieties are recommended over common or Dutch white clover because of superior forage production.

Red clover (*Trifolium pratense*) (Figure 2-11) and **alfalfa** (*Medicago sativa*) (Figure 2-12) are erect legumes that regrow from crowns. Red clover stands last two to three years while alfalfa can persist for five years or more with good management. These erect legumes are most often harvested as hay with companion grasses, such as tall fescue or orchardgrass, but can be grazed effectively with good rotational stocking. Red clover has hairy stems that can cause the hay to be dusty.

Annual lespedeza (*Kummerowia striata* (common or striate) and *Kummerowia stipulacea* (Korean)) is a fine-stemmed, leafy, annual legume with shallow taproots. It produces forage in mid- to late summer and is non-bloating (Figure 2-13). Tolerant of low fertility and acidic soils, it grows 1 to 2 feet tall. Annual lespedeza leaves are a pale green color with light-colored, easily-visible veins. This legume flowers and sets seed in late summer and early fall and must set seed each year to persist. Annual lespedeza may fail to reseed if overgrazed, autumns are dry, or early frost occurs. Kobe and Korean are examples of annual lespedeza.

Figure 2-10. White clover.

Figure 2-11. Red clover.

Figure 2-12. Alfalfa.

Figure 2-13. Annual lespedeza (striate shown).

Cool-season Perennial Grasses

Tall fescue (*Schedonorus arundinaceus)* is a long-lived perennial cool season grass that is adapted to a wide range of soil and climate conditions (Figure 2-14). Tall fescue is the most widely grown forage in Kentucky, and Kentucky 31 (KY-31) is the most common variety found. Since its release in 1943, this variety quickly became the most widely grown pasture grass in Kentucky and in the Southeastern United States. The original KY-31 variety was highly infected with the toxic endophyte of tall fescue. The presence of this internal fungus contributes to the persistence of KY-31, but adversely impacts animal performance. New novel endophyte tall-fescue varieties combine a beneficial endophyte that strengthens the plant, but does *not* produce the toxins that adversely impact animal performance. In most cases, producers should utilize novel endophyte tall fescue when establishing permanent pasture.

Orchardgrass (*Dactylis glomerata*) is an erect-growing cool season bunchgrass that provides high quality hay and pasture (Figure 2-15). Orchardgrass is in high demand as hay and is the preferred companion grass in alfalfa and red clover hay. Orchardgrass requires better management to persist, but stand life may not exceed four years. Orchardgrass stand life is reduced by grazing or cutting lower than four inches.

Kentucky bluegrass (*Poa pratensis*) is a sod-forming, fine-bladed cool season grass most commonly found on better soils in Central Kentucky (Figure 2-16). Kentucky bluegrass is slow to establish and goes dormant during hot, dry summers. High in quality but moderate yielding, it is better adapted for pasture than hay.

Perennial ryegrass (*Lolium perenne*) is a short-lived perennial cool season grass that is very palatable to livestock (Figure 2-17). Perennial ryegrass is easy to establish, has high seedling vigor and is often used to overseed damaged pastures. Stand life of perennial ryegrass is only two to three years, and less during hot, dry years.

Figure 2-14. Tall fescue.

Figure 2-15. Orchardgrass.

Figure 2-16. Kentucky bluegrass.

Figure 2-17. Perennial ryegrass.

Warm-season Annual Grasses

Warm-season annual grasses can provide high-quality forage during midsummer when cool season species are less productive (Figure 2-18). The advantages of summer-annual grasses include fast germination and emergence, rapid growth, high productivity, and flexibility of utilization. Disadvantages include the cost of establishment and the increased risk of stand failure due to variable rainfall in late spring and early summer.

Summer annual grasses are best used in a rotation with small grains or annual ryegrass to optimize productivity per unit of land area. They also have great utility as transition crops prior to the establishment of improved perennial forage species. The sorghum species have prussic acid potential and are hosts for the sug-

Figure 2-18. Warm-season annual grasses such as this sorghum-sudangrass hybrid provide needed forage during summer, when cool season grasses are less productive.

Table 2-2. Characteristics of commonly used summer annual grasses.

Summer Annual	Yield potential in Ky.	Seedling vigor	Tolerance to			Suitability for			Host for sugarcane aphid	Nitrate toxicity potential[1]	Prussic acid potential[2]
			Soil acidity	Poor drainage	Drought	Silage	Hay	Grazing			
Crabgrass	Good	Fair	Poor	Fair	Good	Fair	Fair	Excellent	Poor	Low	None
Forage sorghum	Excellent	Good	Poor	Poor	Excellent	Excellent	Poor	Poor	Good	High	High
Foxtail millet	Fair	Good	Good	Fair	Good	Fair	Good	Fair	---[3]	Low	None
Pearl millet	Good	Fair	Excellent	Poor	Excellent	Good	Fair	Good	Poor	High	None
Sorghum-sudangrass	Good	Excellent	Poor	Fair	Good	Good	Fair	Good	Good	High	Medium
Sudangrass	Good	Excellent	Poor	Fair	Good	Good	Good	Good	Good	High	Medium

[1] See ID-217: "Forage-related Cattle Disorders—Nitrate Poisoning."
[2] See ID-220: "Cyanide Poisoning in Ruminants."
[3] Little information available.

arcane aphid. In addition, nitrate toxicity can be a problem for all summer annuals during drought conditions and high N fertilization. Concerns regarding prussic acid and nitrate toxicity are limited by careful management (See ID-220: *Cyanide Poisoning in Ruminants* and ID-217: *Forage-related Cattle Disorders: Nitrate Poisoning.*) The major characteristics of these grasses is summarized in Table 2-2.

Sudangrass [*Sorghum bicolor* (L.) ssp. *Drummondii*] is a rapidly growing annual grass of the sorghum family. It is medium yielding and well-suited for grazing. Sudangrass regrows quickly after harvest and can be grazed several times during summer and early fall. This grass has finer stems than most other summer annuals making it well suited for hay production. For more information, see AGR-234: *Sudangrass and Sorghum-sudangrass Hybrids.*

Sorghum-sudangrasses (*Sorghum bicolor*) are hybrids or crosses between sorghum and true sudangrass. The result is a tall growing annual grass that resembles sudangrass, but has coarser stems, taller growth habit, and higher yields. Like sudangrass, sorghum-sudangrass will regrow after grazing if growth is not limited by environmental factors. The coarse stems are difficult to cure as dry hay, therefore these grasses are best utilized for grazing, chopped silage and baleage. For more information, see AGR-234: *Sudangrass and Sorghum-sudangrass Hybrids.*

Forage sorghum (*Sorghum bicolor*) can reach heights of 6 to 15 feet and is best harvested as silage. Taller varieties produce high forage yield but can lodge, making them difficult to harvest mechanically. Dwarf varieties have been developed that are shorter with increased resistance to lodging. Like corn, forage sorghums are harvested once per season by direct chopping. While forage sorghum yields can be similar to corn, they are lower in energy. The primary advantage of choosing sorghum for silage production rather than corn is greater drought tolerance. For more information, see AGR-230: *Forage Sorghum.*

Foxtail millet (German millet) is fine stemmed, has no prussic acid potential and is well suited for hay-making. It is the lowest yielding of the summer annual grasses since it will not regrow after cutting. It is a good smother crop when used before notill seeding another crop such as tall fescue or alfalfa. Foxtail millet is also used for wildlife plantings to produce food and cover for doves, quail, and other birds. For more information, see AGR-233: *Foxtail Millet.*

Pearl millet (*Pennisetum glaucum*) is not related to foxtail millet and is higher yielding. It will regrow after harvest, does not have prussic acid potential and is not a host of the sugar cane aphid. Dwarf varieties are available which are leafier and better suited for grazing. Pearl millet is better adapted to acidic soils and drought-prone soils than sorghum, sudangrass or sorghum-sudangrass hybrids. For more information, see AGR-231: *Pearl Millet.*

Crabgrass (*Digitaria spp.*) is sometimes considered a weed, but possesses significant potential for supplying high quality summer forage. Crabgrass does not have prussic acid potential and is a poor host for the sugarcane aphid. Crabgrass is the general term for many Digitaria species. A primary advantage of crabgrass is that it is well adapted to Kentucky and occurs naturally in most summer pastures, especially those that have been overgrazed. It is also highly palatable and a prolific reseeder. With proper management, crabgrass stands can regenerate themselves each spring. Planting an improved variety of crabgrass is recommended because the production of naturally occurring ecotypes varies greatly. Although crabgrass is best utilized by grazing, it can be hayed. For more information, see AGR-232: *Crabgrass.*

Teff (*Eragrostis tef*) is an annual, warm-season grass native to Ethiopia. Teff is characterized by a fairly large crown, many tillers, fine stems, a very shallow root system, rapid growth and moderate yield. When vegetative, teff plants look somewhat similar to tall fescue in size and color. Teff tends to germinate quickly with good moisture and regrows quickly after cutting. With timely planting and good management, multiple cuttings are possible before fall. Teff is poorly adapted for temporary pasture because it tends to be uprooted when grazed.

Warm-season Perennial Grasses

Like annuals, warm-season perennials are very productive in summer and complement the seasonal production of Kentucky's cool season forage base (Figure 2-19). These grasses are somewhat slow and expensive to establish. However as long-lived perennials, the establishment costs can be spread over many years, lowering their annual cost of production over time.

Figure 2-19. Warm-season perennial grasses such as this eastern gamagrass can be important additions to Kentucky's cool season-based forage system.

Bermudagrass *(Cynodon dactylon)* is an introduced sod-forming grass used for hay and pasture. Bermudagrass spreads by underground rhizomes and stolons, and requires high levels of N and K fertilizer for best yields. Although found more frequently in the lower South, winterhardy types of bermudagrass can be successfully grown in Kentucky. Hybrid bermudagrasssess are higher in quality and palatability than common types but are typically less winter hardy. Hybrids can only be established by planting vegetative sprigs. There are several seeded types adapted to Kentucky (see AGR-48: *Bermudagrass: A Summer Forage in Kentucky*).

Eastern Gamagrass *(Tripsachum dactyloides*) is a coarse, tall growing native warm season bunchgrass. Eastern gamagrass has high yields and is highly palatable to livestock. It provides more uniform growth over the summer than switchgrass, big bluestem, or indiangrass. Eastern gamagrass will grow on wet sites. This grass is somewhat expensive to seed. Seed can have high levels of dormancy leading to slow, uneven emergence and establishment. It must be rotationally grazed and rested in fall to persist.

Switchgrass *(Panicum virgatum)* is a tall-growing deep-rooted rhizomatous native bunchgrass. Some varieties are tolerant of wet sites. Switchgrass can be used for hay, pasture and wildlife. Advantages include being drought tolerant, using N efficiently, and having seed that will flow through conventional seeders. Like other native warm season grasses, switchgrass is slow to establishment, has low seedling vigor and requires rotational grazing and fall rest to persist. Animal gains are poor when mature. The growth season of switchgrass also overlaps with cool season perennial grasses in late spring.

Figure 2-20. Cool-season annual grasses such as small grains can extend the grazing season in the fall and early spring (wheat shown).

Big Bluestem *(Andropogon gerardii)* is a tall-growing deep-rooted bunchgrass. It is more drought tolerant than most warm season perennial grasses and is suitable for hay, grazing and wildlife. Big bluestem is palatable over a wider range of maturities than switchgrass. It is an efficient user of fertilizer N but is slow and expensive to establish. Seed of big bluestem is light and requires no-till drills that can handle fluffy seed. Like other native grasses, it will not tolerate close, continuous grazing.

Indiangrass *(Sorghastrum nutans)* is a tall growing, deep-rooted bunchgrass. It is drought tolerant, and is spread by rhizomes and seed. Indiangrass matures later than switchgrass and big bluestem, which extends the grazing season into late summer. Like big bluestem, its seed is light and requires no-till drills that can handle fluffy seed. Like other native grasses, it will not tolerate close, continuous grazing.

For more information see AGR-145: *Native Warm-season Perennial Grasses for Forage in Kentucky*.

Figure 2-21. Annual ryegrass is an important forage when high quality spring pasture is needed.

Cool-season Annuals

Cool-season annual grasses that can be used for winter and early spring grazing include small grains (Figure 2-20) and annual ryegrass (Figure 2-21). Characteristics of these forage crops are summarized in Table 2-3. The annual forage crimson clover can be grown in a mixture with both the small grains and annual ryegrass.

Wheat (*Triticum aestivum*) is one of the most versatile small grains for a farming operation. Due to its excellent winter hardiness, wheat can be sown later in the fall than barley and has good potential for pasture, silage or hay production. Wheat will withstand wetter soils better than barley or oats, but tends to be less tolerant of poorly drained soils than rye, triticale, and annual ryegrass. Managed properly, wheat can be grazed in the fall, again in early spring, and finally harvested for grain, hay, or silage.

Barley (*Hordeum vulgare*) is generally more susceptible to winterkill than wheat, especially when it has been overgrazed. It should not be grazed as short or as late into the fall as wheat. Barley does best on fertile, well-drained soils. It is sensitive to acidic soil conditions and poor fertility. Barley produces high quality silage or hay with a higher digestibility than other small grains, but lower yields. Good quality grazing can be obtained from early seeded barley.

Triticale (X *Triticosecale*) is a high yielding forage crop that is gaining popularity. Triticale generally has a higher forage yield, but lower quality than wheat. It is a

Table 2-3. Characteristics of commonly used cool season annual grasses.

Cool season annual	Yield potential[1] Tons DM/A	Fall Growth	Winter-hardiness	Tolerance to		Suitability for		
				Soil acidity	Poor drainage	Silage/ baleage	Hay	Grazing
Annual ryegrass	3-4[2]	Good	Fair – Good[3]	Good	Good	Excellent	Good	Excellent
Barley	1.5-2	Good	Good	Poor	Poor	Excellent	Good	Good
Oats	2-2.5	Excellent	Poor - Fair	Fair	Fair	Excellent	Good	Good
Rye	2.5-3	Excellent	Excellent	Good	Fair	Good	Fair	Good
Triticale	2-3	Good	Good	Good	Fair	Good	Fair	Good
Wheat	2-3	Good	Excellent	Poor	Fair	Excellent	Good	Good

[1] Harvested at boot stage.
[2] Multiple harvests.
[3] Dependent on variety.

cross between rye and wheat. As such, it is adapted to a wide range of soils. Tolerance to low pH is better than wheat, but not as good as rye.

Rye (*Secale cereale*) is the most cold tolerant and least exacting in its soil and moisture requirements of all small grains. Like wheat, rye can be sown in late August to provide fall grazing, excellent winter ground cover, and spring grazing. The rapid growth of rye, both in the fall and spring, makes it the most productive of the small grains for pasture. Rye is also the earliest maturing of the small grains. Rye tends to be a more consistent producer of spring pasture than wheat, although it quickly becomes stemmy and unpalatable in late spring.

Winter Oats (*Avena sativa*) produce very palatable forage and are best adapted to well-drained soils. They do not perform as well under extremely dry or wet conditions as wheat or rye. Although oats produce high quality forage, yields tend to be lower than the other small grains. As a rule, the hardiest winter oat variety (Kenoat) is considerably less winter hardy than common wheat, rye and barley varieties. In Kentucky, oats will usually overwinter 50 percent of the time. Similar to barley, winter oats must be seeded by mid-September to be well established before cold weather arrives. Spring oats are the most commonly planted early season annual hay crop and can produce 1.5 to 2 tons of forage in 60 days when planted in mid-March.

Annual ryegrass (*Lolium multiflorum*) is a cool-season annual that can provide late fall, winter, and early spring grazing. Attributes of annual ryegrass include ease of establishment, high yields, high nutritive value, and later maturity than the small grains. In contrast to small grains, annual ryegrass continues to regrow in the spring until high temperatures limit growth in early summer. Annual ryegrass is commonly used to overseed warm season summer pastures in the Deep South and can be used to thicken up thin cool season pastures in transition zone states like Kentucky. It is adapted to all soil types and grows best at a pH of 5.7 or higher. The highest yields are obtained on fertile and well-drained soils with high N fertilization.

Crimson clover (*Trifolium incarnatum*) is a winter annual legume with conical bright red blooms and dark green leaves densely covered with hairs (Figure 2-22). It can be used with small grains or annual ryegrass and is suitable for grazing, hay or haylage but quality is low when mature. Crimson is not adapted to poorly drained soils. The recently released variety "Kentucky Pride" is the most winter hardy crimson clover on the market.

Figure 2-22. Crimson clover.

Understand and Managing Tall Fescue and the Toxic Endophyte

Tall fescue is the most widely adapted and persistent perennial grass in Kentucky. Most tall fescue in Kentucky originates from the KY-31 variety found on the W.M. Suiter farm in Menifee County. Kentucky 31 tall fescue was quickly adopted by farmers across Kentucky because the agronomic characteristics were superior to all other cool season perennial forage grasses. Animal performance when grazing KY-31 tall fescue, however, was not.

Unknown at the time, the original seed was infected with a fungal endophyte (*Acremonium coenophialum*). The presence of this fungal endophyte causes the host fescue plant to produce compounds called ergot alkaloids that adversely impact cattle performance, especially during hot weather. This condition is called "summer syndrome," "summer slump," "fescue toxicosis," and "fescue toxicity." Baleage, hay, and/or seed from toxic tall fescue can negatively affect animals that consume them.

The fungus spends its entire life inside the fescue plant and is spread only by seed. The presence of the fungus can only be detected by a laboratory analysis and does not change the appearance of the plant. Because it is spread by seed, a field established with non-infected seed can be expected to remain free of the endophyte unless infected seed is introduced through hay, birds, equipment or manure.

The ergot alkaloids in tall fescue cause a narrowing of the veins or vasoconstriction in the extremities of cattle which interferes with heat dissipation. Cattle grazing tall fescue in summer will show signs of heat stress, such as higher respiration rates, higher body temperatures and more time spent in ponds and shade (Figure 2-23). During cold weather, toxicosis symptoms may include loss of the tips of

Figure 2-23. Cattle grazing toxic tall fescue exhibit symptoms of heat stress and will spend excessive amounts of time in ponds or shade.

ears and tail and in extreme cases lameness and hoof loss (fescue foot).

Consumption of toxic tall fescue also causes lower forage intake, lower weight gains, lower milk production, rough hair coats, less time spent grazing, reduced blood serum prolactin levels, and reduced reproductive performance in both cows and bulls.

Surveys of Kentucky pastures consistently show that 80 percent or more of the fescue present is infected with the endophyte. The economic effect of toxic tall fescue on the beef industry is significant. Toxic tall fescue is known to reduce conception rates by 10 percent or more and weaning weights by 50 pounds. Across 1.1 million beef cows, this amounts to 110,000 fewer calves to sell and approximately 45 million fewer pounds to sell at weaning (900,000 calves x 50 pounds per calf). The lower calving rates alone could total $82.5 million if calves are worth $750. Beef cattle producers have an economic incentive to find ways to deal with toxic tall fescue.

The discovery that the endophyte was to blame for the negative animal performance led to the development of tall fescue varieties that were free of the toxic endophyte. Animal performance from these varieties was superior, but persistence of these endophyte-free fescues was less than desired. New Zealand scientists discovered naturally occurring strains of the endophyte that did not cause the production of toxic alkaloids in tall fescue. These endophyte strains have been inserted into locally adapted tall fescue to produce novel endophyte varieties which have been commercially available since the late 1990s. These new products are also referred to as friendly, beneficial or non-toxic tall fescue varieties. Novel endophyte tall fescues have been observed to have greater persistence than comparable endophyte-free fescues. Novel or friendly endophyte varieties give animal performance similar to endophyte-free tall fescue, but their persistence is similar to KY-31 plants that contain the toxic endophyte as long as they are not overgrazed.

Since it would be impractical to replace all existing tall fescue acres in Kentucky with novel endophyte varieties, producers are encouraged to manage the toxic effects of endophyte-infected tall fescue using one or more of following methods:

Minimize the effects of the endophyte on animals with management practices. Grazing and/or clipping management that keeps plants young and vegetative results in better animal performance. If tall fescue is cut for hay in the vegetative or boot stage, better animal performance is obtained than from mature hay containing seedheads. Not only are the leaves higher quality that the stems, but tall fescue leaves contain lower concentrations of the toxin (ergovaline) that causes animal issues than the stem and seedhead. Other practices, such as chain harrowing, fertilizing, pest control, creep grazing, and stockpiled rotational grazing, result in improved overall pasture quality and animal performance.

Avoid the endophyte by using other forage species. Using infected tall fescue primarily for early spring and late fall grazing and other grasses or grass-legume mixtures for summer grazing avoids tall fescue endophyte issues during the summer when toxic effects are greatest and tall fescue forage quality is low. Feeding hay of another species can also be helpful.

Dilute the endophyte with clover. Growing legumes with infected fescue is an attractive option and is highly recommended. Many studies have shown increased pasture production, higher liveweight gains, and improved pregnancy rates when pastures are renovated to include legumes like red and ladino white clover. Clover introduction has been the number one strategy used by Kentucky producers for diluting the toxic effects of the endophyte.

Kill infected stands and replant. In some cases, it is beneficial to completely kill the existing toxic tall fescue and replace it with a more desirable forage. Options include orchardgrass or one of the perennial warm season grasses. Endophyte-free, or novel endophyte fescue varieties are options also.

The cost of converting existing fescue to an endophyte free or novel endophyte fescue can be significant in terms of herbicide, seed, drilling and lost production. However, costs are recovered in two to three years because of the significant improvement in animal performance.

For no-till seedings, completely kill the existing tall fescue with two applications of glyphosate spaced 4 weeks apart. The first application should generally occur by mid-July and the second application in late August followed by seeding in early September. It is important to have at least 4 to 6 weeks between the first glyphosate treatment and grass seeding to allow the killed grass to decay and not interfere with seedling emergence. Do not let tall fescue produce seed in the year of re-establishment.

Forage Establishment

The establishment of a good stand of desirable forage is essential to a successful forage program. High yields require thick, vigorous stands which will also prevent weed encroachment. In addition, thick stands prevent or minimize soil erosion. The following recommendations are the basics of successful forage establishment:

- Match plants to soils.
- Match plants to intended use.
- Select high-quality seed of an adapted variety.
- Supply proper fertility.
- Prepare an adequate seedbed.
- Use the best seeding method available.
- Seed at the right time and rate.
- Get good seed-soil contact.
- Control competition from other plants after establishment.
- Allow forages to become established before heavy use.

The goal of any seeding method is to place the proper amount of seed at the right depth and in good contact with soil (Figure 2-24). Prepared seedbeds should be fine-textured and firm enough so footprints are not more than ¼ to ½ inch deep.

Figure 2-24. A successful seeding method places the correct amount of seed at the proper depth and in good contact with soil.

Figure 2-25. Clipping pastures is an important tool in weed management.

Planting too deep happens frequently when seedbeds are too fluffy. To ensure proper depth and good seed-soil contact when planting on a prepared seedbed, pack the soil before and after seeding by rolling with a corrugated roller (cultipacker). A Brillion® seeder combines seeding and cultipacking in one operation.

With no-till seedings, soil moisture is preserved and residue is present on the surface to slow drying of the soil surface. No-till seeders are designed to cut through sod and crop residue. Adjustment of seeding depth may be required with each field. **Planting too deeply is the most common cause of seeding failures with no-till drills.** The press wheels of drills ensure good seed soil contact after depositing the seed in the furrow.

Frost seeding refers to the practice of broadcasting seed on top of the ground during winter, relying on freeze/thaw cycles to work the seed into the soil. Frost seeding is recommended only for clover. Pastures should be very closely grazed or clipped prior to frost seeding in late January or February. Seeding grasses via frost seeding is generally not successful.

An Integrated Approach to Weed Control in Pastures

In many cases, producers equate weed control with the use of herbicides. While herbicides effectively control many weed species commonly found in pastures, long-term weed control in pastures should have a broader strategy. The best weed control strategy is to have an integrated approach that includes cultural practices that encourage a healthy and vigorous sod, proper grazing management, timely clipping, as well as judicial use of herbicides.

Maintaining thick stands of perennial grasses. Thick, vigorous, well-fertilized stands of grass prevent the encroachment of most weeds. Proper grazing management that includes maintaining critical residual heights will help keep stands competitive and less prone to significant weed problems.

Clipping pastures. Mowing pastures can control or at least inhibit the spread of some weeds species, but the cost may be greater than other options (Figure 2-25). It is estimated that clipping can cost between $15 and 20/acre. If timed correctly, clipping can reduce weed seed production. However, if performed after weeds have produced viable seed, it can actually worsen weed problems by spreading seeds. Clipping is also less effective on plants with large underground root systems and plants that have low growth habits.

Herbicide use. There are a number of very effective herbicides to control difficult broadleaf pasture weeds. The UK publication AGR-207: *Broadleaf Weeds of Kentucky Pastures* shows pictures of weeds along with a chart that lists of the weeds, the herbicides that will control each one, and the time of the year that is best to spray (Table 2-4).

For weeds that grow or germinate in cooler months like bull, musk and plumeless thistle the time to spray is October to November or February to March. Spraying during these months kills the thistle plants when they are small. On the other hand, weeds like buttercup and poison hemlock often do not germinate until late winter, so the most effective time to spray is early March to early April. Other problem weeds only grow in the summer months. For example, the best time to spray tall ironweed is June-August or to spray ragweed is May-July. Spray at the right time and use the recommended products and soon your pastures and hayfields will be almost weed free. Remember the best weed control is good grazing and cutting management and a well fertilized forage stand has the best chance to outcompete weeds.

Commonly used broadleaf herbicides injure or kill clover and other legumes. In some cases, herbicides can be spot applied to smaller areas within pastures or applied with a wicking or wiping device to taller growing weeds to spare the clover. More information on herbicide use in pastures can be found in AGR-172: *Weed Management in Grass Pastures, Hayfields, and Other Farmstead Areas.*

Forage Growth and Grazing Management

Improved grazing systems allow beef cattle to more efficiently and economically harvest forage. Therefore, it is very important to understand how grasses and legumes grow and how these plants respond to defoliation by grazing.

The growing point of grasses is at or near the soil surface, while that of legumes is elevated above the ground (white clover is an exception). When grasses are grazed, only leaf area is removed and the growing point stays intact. After grazing, grasses have more residual leaf area with which to support new growth compared to legumes which rely more on stored carbohydrates.

With upright legumes, such as red clover and alfalfa, grazing removes the growing tip. New shoots must come either from crown buds or from the lower portions of shoots. The energy for this new growth comes almost totally from carbohydrates stored in the crown. These carbohydrates need to be replenished during a "rest" period following grazing.

Overgrazing of grasses takes away the residual green leaf area needed to support new growth. Grasses use stored carbohydrates in the base of each tiller for regrowth, therefore rest periods and

Table 2-4. Response of Pasture Weeds to Herbicides and Mowing.*

Weed Species	Life Cycle[1]	Preferred Time for Herbicide Treatment[2]	2,4-D	dicamba (Banvel/Distinct)	dicamba + 2,4-D (Weedmaster)	Crossbow	PastureGard	Milestone	GrazonNext	metsulfuron[3]	MOWING[4]
Amaranth, Spiny (Pigweed)	A	May-July	F/G	F/G	G	G	F/G	F	G	G	X
Aster spp. (White Heath Aster)	A	July-Sept	F/G	G	G	G	-	-	-	F	R
Burdock, Common	B	Feb-Mar	G	F	G	G	G	F	G	F	R
Buttercup spp.	A	Feb-Mar	G	F/G	G	G	F	F	G	G	X
Carrot, Wild (Queen Anne's Lace)	B	May-June	G	G	F/G	F/G	F	P	G	G	R
Chickweed, Common	A	Nov or Feb-Mar	P	F/G	G	F	G	G	G	G	X
Chicory	P	Feb-Mar or Aug-Nov	F/G	F/G	G	G	G	G	G	F/G	R
Clover, White	P	May-Aug	F/G	G	G	G	G	G	G	G	X
Cocklebur, Common	A	May-July	G	G	G	G	G	G	G	G	R
Dandelion	P	Oct-Nov or Mar-Apr	G	G	G	G	F/G	F/G	G	G	X
Deadnettle, Purple	A	Feb-Mar	P	F/G	G	F	G	G	G	G	X
Dock, Curly or Broadleaf	P	Feb-Apr	P/F	F	F/G	G	F/G	G	G	G	X
Dogbane, Hemp	P	May-Aug	F	F	F	F/G	G	P	P/F	P	S
Garlic, Wild	P	Nov or Mar-Apr	F	F	F	F	P	P	F	G	X
Goldenrod spp.	P	June-Aug	F	F/G	G	G	G	P	F/G	P	S
Hemlock, Poison	B	Nov or Mar-Apr	F/G	G	F	F/G	P	P	F/G	F	R
Henbit	A	Feb-Mar	P	F/G	G	F	G	G	G	G	X
Horsenettle	P	July-Aug	P	F	F	F	P	G	G	F	X
Ironweed, Tall	P	June-Aug	P	P/F	F	G	G	G	G	P	S
Jimsonweed	A	May-July	F	G	G	G	-	G	G	-	R
Lespedeza, Sericea	P	June-July	P	P/F	P/F	G	G	P/F	P/F	F/G	X
Marshelder (Sumpweed)	A	May-July	F/G	F/G	G	G	F	F/G	G	F	R
Milkweed, Common	P	July-Sept	P	F	F	F	P/F	P/F	P/F	P	S
Mint, Perilla	A	May-July	F	F	F/G	G	F/G	-	G	-	S
Multiflora Rose	P	Apr-June or Sept	P/F	P	F	G	G	P	P	G	X
Passionflower, Maypop	P	May-July	P	-	P	-	F	P	P	-	X
Plantain, Broadleaf or Buckhorn	P	Oct-Nov or Mar-Apr	F/G	F	F/G	G	F	P	F/G	F/G	X
Pokeweed, Common	P	May-July	F	G	F/G	F/G	P	F/G	F/G	P	S
Ragweed, Common	A	May-July	G	G	G	G	G	G	G	P	R
Ragweed, Lanceleaf	A	May-July	F/G	G	G	F	-	-	-	P	R
Sorrel, Red (Sheep Sorrel)	P	Sept-Nov or Mar	P	G	F/G	F/G	F	-	-	F/G	X
Thistle, Bull	B	Oct-Nov or Feb-Mar	G	G	G	G	F/G	G	G	F/G	R
Thistle, Canada	P	Prebud or Oct-Nov	P	P/F	F	F	P/F	G	G	F	S
Thistle, Musk	B	Oct-Nov or Feb-Mar	G	G	G	G	F/G	G	G	F/G	R
Thistle, Plumeless	B	Oct-Nov or Feb-Mar	G	G	G	G	F/G	G	G	F/G	R
Trumpetcreeper	P	Aug-Sept	P	P/F	P/F	F	F	P	P	P	X
Yarrow, Common	B	Feb-Mar	G	G	G	-	-	-	-	F/G	X

Control: **G** = Good or Excellent; **F** = Fair (suppression or partial control); **P** = Poor; **–** = No Information

[1] Life Cycle: **A** = Annuals; **P** = Perennials; **B** = Biennials.
[2] The preferred time for herbicide treatment will depend on environmental conditions and other factors.
[3] Active ingredient in several products (e.g. Cimarron, Patriot, Purestand). May cause temporary yellowing, stunting and seedhead suppression of tall fescue (consult label).
[4] Mowing: **R** = Timely mowing reduces top growth and seed production; **S** = Suppression of top growth; **X** = Not very effective

This table should be used only as a guide for comparing the relative effectiveness of herbicides to a particular weed. The herbicide may perform better or worse than indicated in the table depending on the species, weed size, time of application and/or extreme weather conditions. Consult herbicide label for weed height or growth stage and product amount. Read and follow all label directions and precautions before herbicide application.

Adapted from AGR-172: *Weed Management in Grass Pastures, Hayfields, and Other Farmstead Sites* (Revised 10-2012).

Listing of pesticide products implies no endorsement by the University of Kentucky or its representatives. Criticism of products not listed is neither implied nor intended.

*From: AGR-207: *Broadleaf Weeds of Kentucky Pastures*, J.D. Green and W.W. Witt, Plant and Soil Sciences.

leaving adequate residual heights can be important for grasses too. Rest and leaving adequate residual after grazing is especially important for orchardgrass (Figure 2-26).

Frequent defoliations hurt legumes more than grasses because legumes rely more on stored carbohydrates for regrowth and because grazing removes their growing point and a high proportion of leaves. In most cases, grazing management should favor the legume which means shorter grazing periods and longer rest periods. Guidelines for rotational stocking of selected forages is found in Table 2-5.

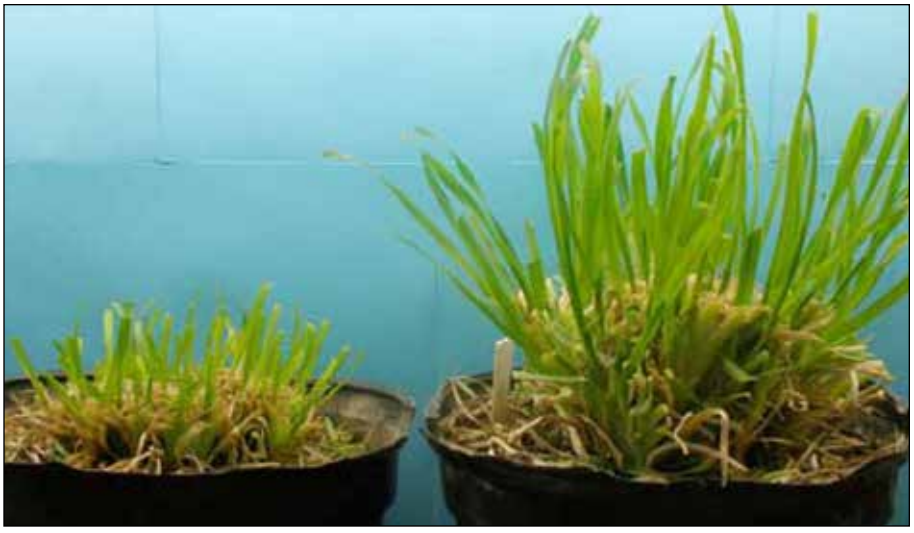

Figure 2-26. Six-days regrowth of orchardgrass plants after being harvested weekly at one inch (left) or monthly at 3.5 inches (right). Close frequent harvest of orchardgrass greatly inhibits regrowth.

Benefits of Improved Grazing Management

Better grazing management benefits Kentucky producers in several ways, including improved utilization, yield, quality, a longer grazing season, stand persistence, animal performance and health, environment, and economics.

Utilization. Grazing methods dictate how much of the overall forage produced is actually utilized by the grazing animal. To better understand this aspect, one should first examine the difference between "temporal" and "full season" utilization. Temporal utilization is defined as how much of the existing pasture we utilize during a grazing period, and full seasonal is the amount of the pasture utilized over the grazing season. Because forage growth rate varies from one grazing period to another (temporally), rotational stocking will allow the manager to more nearly allocate pastures so less forage is wasted. In a continuous grazing program, the manager is less able to alter stocking rates with growth rates, leading to waste. Therefore continuous grazing programs only utilize a small amount of the total pasture produced for the season compared to well-managed rotational systems (Table 2-6).

Yield. Pasture plants grow at different rates throughout the growing season. Kentucky's cool-season grasses grow best in spring, well in late-summer/fall, and little during summer and winter. Amount of growth during each period is dependent on temperature and moisture. With continuous grazing, it is difficult to keep pasture plants in their most efficient photosynthetic growth stage. In these systems, some plants are overgrazed, while others are avoided as they become mature. This uneven grazing is especially a problem during periods of spring surplus. With rotational grazing, it is possible to keep plants at a more efficient growth stage (i.e.vegetative) that can result in more animal product per acre (Table 2-7). During spring surplus, selected paddocks can be harvested for hay or haylage.

Quality. Forage quality is highest when pasture plants are young and vegetative. Pasture quality is very closely related to the proportion of leaves in the sward. With rotational grazing, one can usually manage leaf content, and ultimately

Table 2-5. Guidelines for Rotational Stocking of Selected Forage Crops.[1]

Crop	Target height, in		Usual days rest
	Begin grazing	End grazing[2]	
Alfalfa (hay types)	10-16	3-4	35-40
Alfalfa (grazing types)	10-16	2-3	15-30
Bahiagrass	6-10	1-2	10-20
Bermudagrass	4-8	1-2	7-15
Bluestem, big	15-20	10-12	30-45
Bluestem, caucasian	10-20	4-6	14-21
Bromegrass, smooth	8-12	3-4	20-30
Clover, white and subterranean[3]	6-8	1-3	7-15
Clovers, all others[3]	8-10	3-5	10-20
Dallisgrass	6-8	3-4	7-15
Eastern gamagrass	18-22	10-12	30-45
Fescue, tall	8-12	4-8	15-30
Indiangrass	12-16	6-10	30-40
Johnsongrass	16-20	8-12	30-40
Kentucky bluegrass	8-10	1-3	7-15
Lespedeza, sericea	8-15	4-6	20-30
Orchardgrass	8-12	4-8	15-30
Pearl millet	20-24	8-12	10-20
Ryegrass, annual	6-12	3-4	7-15
Small grains	8-12	3-4	7-15
Sorghum, forage	20-24	8-12	10-20
Sorghum/sudan hybrids	20-24	8-12	10-20
Switchgrass	18-22	8-12	30-45

[1] These are merely guidelines. Stocking rates and growing conditions greatly affect forage growth. Also, the more closely pastures are grazed, the longer the rest period generally needs to be for species that are sensitive to defoliation.

[2] The nutritional requirements of the livestock being grazed should be considered when deciding when to end grazing. The closer a pasture is grazed, the lower forage quality will be toward the end of that particular grazing cycle.

[3] Clovers are typically grown with pasture grasses. White clover and subterra nean clover are quite tolerant of close defoliation; most other clovers are not.

Used with permission from 2017 Forage Crop Pocket Guide, 14th Edition, p. 37.

Table 2-6. Amount of forage utilized with different grazing methods.

Method	% Utilization*
Green chop	85 - 95
Haylage	80 - 95
Hay	70 - 85
Strip grazing	70 - 85
Rotation two times/day	70 - 80
Daily rotation	60 - 75
Rotation every two days	55 - 70
3- to 7-day rotation	50 - 70
3- to 5-week rotation	40 - 60
Continuous grazing	20 - 50

* These values should be used only as a guide. Considerable variation can exist within and among categories.

Table 2-7. Gain per acre, gain per animal, and hay required for wintering a beef cow using different grazing methods.

	Percent Change of Rotational over Continuous Grazing
Stocking rate	+38
Calf gain/acre	+37
Hay fed/cow	-32

Source: Dr. Carl Hoveland, Univ. of Georgia.

Table 2-8. Percent leaves and persistence with different grazing methods.

	Grazing Method	
	Rotational	Continuous
Percent leaves	46 - 49	31 - 36
Percent stand (3rd yr.)	84	62

Source: Mathews et al. Univ. of Florida. 1994.

quality, better than using most continuous methods (Table 2-8). In addition, quality for most of Kentucky tall fescue-based pastures is usually associated with legume content. With various rotational grazing methods, legumes can be better managed to keep them more productive and persistent than under continuous grazing methods.

The yield/quality relationship can be better explained by examining the gain per acre (yield) and gain per animal (quality) relationship (Figure 2-27). As stocking rate is increased, less forage is available per animal. Individual animal output decreases as animals compete for forage and have less opportunity to select green, leafy forage. As a result of increased forage utilization, animal output per acre increases with stocking rate until individual animal gains are depressed to the point that the additional animals carried do not compensate for the loss. At high stocking rates, photosynthesis is reduced due to insufficient leaf area, plants are weakened, and forage growth is depressed.

Longer Grazing Season. When improved grazing methods are used, forage utilization usually increases and "waste" decreases. With decreased waste, more pasture is available for grazing over a larger period of time. Missouri workers used a strip-grazing approach to utilize stockpiled tall fescue. Allocating a new strip of stockpiled fescue every three days rather than every two weeks increased carrying capacity by 56 percent. Farmers consistently find that during drought conditions, rotational grazing methods result in more pasture over a longer period of time compared to continuous grazing.

Stand Persistence. Many pasture plants can be grazed continuously and continue to persist. Examples include Kentucky bluegrass, bermudagrass, endophyte-infected tall fescue, and white clover. Other plants will not persist for long when continuously overgrazed. Examples include alfalfa, most warm-season perennial grasses, and warm-season annuals. Even the plants capable of withstanding continuous grazing will usually be more productive under a grazing method that permits time for rest and regrowth.

Animal Performance. Performance per animal can decline under intensive grazing because the animals cannot be as selective in what they consume. However, gain per acre can increase if stocking rates are increased to consume available forage in a timely manner (Table 2-7).

Animal Health. When using a system that requires moving animals regularly, cattle are monitored more frequently, increasing the chance to catch herd health problems. Controlling problems before they get serious is a health benefit for the animal and an economic benefit for the owner.

Environment. Improving grazing systems can have a positive impact on the environment, especially water quality. Most improved grazing systems involve reducing pasture size, creating more water points, and often fencing animals out of ponds and streams or designing limited access. Systems that keep animal manure and urine out of the water supply will improve water quality.

Economics. Simply changing to a rotational grazing system will not guarantee a profit. Putting in more fences and water will increase costs and will fail to be profitable if they do not fit into the overall plant-animal-environment system. Improved grazing systems do offer many opportunities to improve the bottom line. However, the most economically sound systems will need to include adequate soil fertility, forage species and varieties matched to the land, well-managed plant pests, pasture quality adequate to meet animal needs, healthy animals that can make best use of pasture available, and an overall plan to optimize grazing and minimize stored feed required.

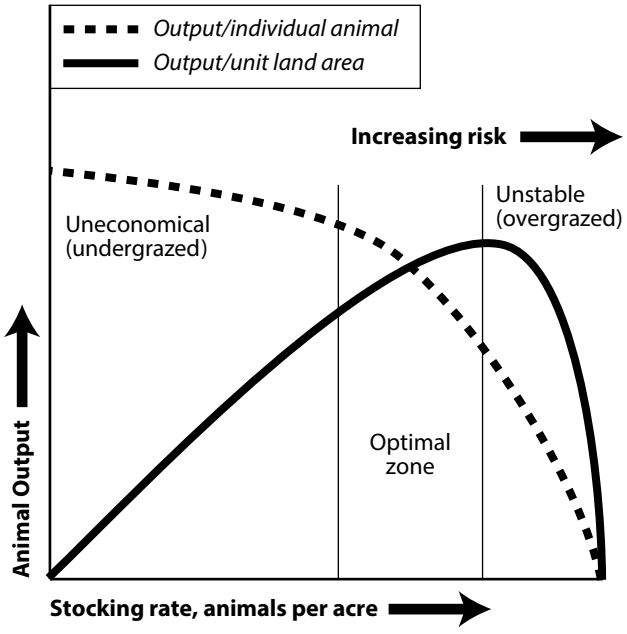

Figure 2-27. Effect of stocking rate on output per individual animal and output per unit of land area.

Developing a Planned Rotational Grazing System

Although producers will readily acknowledge the benefits of a planned rotational grazing system, they struggle to implement one. The following simple steps can help farmers develop an improved and effective grazing system on their farm.

Step 1: Set a Goal

A producer should first ask the simple question, "What do I want to accomplish?" The good news is there are really no wrong or right answers. While most tend to focus on production/economic related goals, lifestyle goals are also important. Some producers find it beneficial to write out their goal statement and keep it where it can refresh their memory on a regular basis. Going through the process of writing farm goals will clarify the process of developing a grazing system.

The following is an example of a reasonable goal statement:

"We want to implement a rotational stocking system that will allow us to feed less hay, maintain good body condition in our cattle herd, protect our soil and water resources, and allow us time to attend our children's extracurricular activities."

Step 2: Inventory Resources

The process of attaining farm forage goals starts by inventorying present system resources. This inventory should include soils, soil fertility, forage base, fencing, water sources and locations, cattle genetics and available labor. Soils, forages, fence and water are the key resources in a forage system.

Soils and soil fertility. Not all soils are created equal. Deep, well-drained, fertile soils have a much higher yield potential than shallow soils with a high percentage of rock fragments. The Web Soil Survey of USDA-NRCS will provide estimates of pasture and hayland productivity. Remember that even on very good soils, forage production can be severely reduced by low soil fertility.

Forage base. The types of forage species present will impact both forage productivity and availability during the summer and winter months. For example, a forage system based solely on cool-season grasses and legumes will have great production during the spring and fall, but limited growth during the summer. In this case, adding a warm-season grass could greatly improve summer grazing capacity.

Figure 2-28. Pasture utilization is more uniform when cattle do not have to walk more than 800 feet to water.

Figure 2-29. A sound rotational grazing system will depend on subdividing larger pastures to pastures to rest between defoliations. Temporary fence posts and polywire can quickly and easily subdivide larger pastures.

Water resources. Access to water is often a major factor restricting the use of rotational grazing (Figure 2-28). Research shows that if water is within 800 feet of cattle, pastures are grazed more uniformly and manure is distributed more evenly over a pasture. When water is farther away than 800 feet, pasture use decreases and overgrazing of areas closer to water occurs.

All potential water sources should be considered when developing a grazing system. Ponds, springs, streams, municipal water and wells are options and can all contribute to providing water to livestock. Using portable water systems initially while developing a grazing system can allow producers to evaluate waterer locations and make better decisions about where to place permanent waterers.

Fencing resources. Fence in a rotational grazing system is simply a tool to manage grazing. One of the most cost-effective ways to subdivide large pastures is to install a single electrified wire 30 inches above the ground on the inside of the perimeter fence using temporary fence posts and polywire (Figure 2-29). This practice creates a flexible system that can be changed and improved as more experience is gained. When starting out, try different temporary fencing components to determine what works best. For more information on fencing for grazing systems follow the link to the UK publication ID-74: *Planning Fencing Systems for Intensive Grazing Management*.

Step 3: Determine Forage Balance

To determine your forage balance, one will need to know how much forage is needed and the production (yield) capacity of pastures. To determine forage needs requires a little simple math. Needed for these calculations are the weight and number of animals being fed/grazed and their expected dry matter intake as a percent of body weight. In this example, there are 100 brood cows that weigh 1,200 lb./cow and four bulls that weigh 1,500 lb. each. All are eating on average 2.5 percent of their body weight each day. To determine their annual dry matter requirements, use the following formula:

DM Required Annually:
100 cows x 1,200 lb/cow
\+ 4 bulls x 1,500 lb/bull
x 2.5%/100
x 365 days
= 1,149,750 lb

For forage supply calculations, annual pasture productivity will be estimated to be 3 ton/A or 6,000 lb. DM/A. Not all pasture grown will be consumed by grazing livestock, so an estimate of forage utilization should be made. Seasonal utilization rates can range from 40 percent to 70 percent and increase as the grazing management intensifies. For this example, set pasture acres at 225 acres with a seasonal utilization rate of 60 percent. Forage available to be grazed can be calculated using the following formula:

Available Forage:
6,000 lb DM/A
x 60% utilization rate/100
x 225 A
= 810,000 lb DM

Calculate the forage balance by subtracting the available DM from the required DM. In this case, there is a deficit of 339,750 lb. DM or about 110 days of hay feeding.

Step 4: Setting a Stocking Rate for Your Farm

Stocking rates that are set too low tend to have the highest production per animal, but lowest production per acre. These stocking rates tend to waste pasture resources due to lower utilization rates and decrease overall profitability. Stocking rates that are set too high tend to have low individual animal performance and low output per acre. These stocking rates tend to be unprofitable because neither the pasture nor the animals are productive. The goal in setting sustainable stocking rates is to find the "sweet spot" where animal performance is good and output per acre is optimized (Figure 2-27). In Kentucky and other transition zone states, greatest net return is achieved when hay feeding is limited to about 60 days per year. Feeding no hay is not normally the most profitable model. However, it is important to note that the economics of hay feeding and grazing are NOT static, but rather change as the price of hay and grazing change.

Producing High Quality Hay and Haylage

The ultimate test of hay quality is animal performance. Quality can be considered satisfactory when animals consuming the hay give the desired performance. Three factors that influence animal performance are: (1) intake—hay must be palatable if it is to be consumed in adequate quantities; (2) digestibility and nutrient content—once the hay is eaten, it must be digested to be converted to animal products; and (3) toxic factors—high-quality hay must be free of components that are harmful to animals consuming it.

Table 2-9. Recommended stages to harvest various forage crops.

	Plant Species	Time of Harvest
1.	Alfalfa	Late bud to first flower for first cutting, first flower to 1/10 bloom for second and later cuttings.
2.	Bluegrass, orchardgrass, tall fescue or timothy	Boot[1] to early head stage for first cut, aftermath cuts at 4- to 6-week intervals.
3.	Red clover or crimson clover	First flower to 1/10 bloom.
4.	Oats, barley, or wheat	Boot to early head stage.
5.	Rye and triticale	Boot stage or before.
6.	Soybeans	Mid- to full bloom and before bottom leaves begin to fall.
7.	Annual lespedeza	Early bloom and before bottom leaves begin to fall.
8.	Ladino clover or white clover	Cut at correct stage for companion plant.
9.	Sudangrass, sorghum hybrids, pearl millet, and johnsongrass	40-inch height or early boot stage, whichever comes first.
10.	Bermudagrass	Cut when height is 15 to 18 inches.
11.	Caucasian bluestem	Boot to early head stage.
12.	Big bluestem, indiangrass, and switchgrass	Early head stage.

[1] Boot is stage of growth of a grass just prior to seedhead emergence. This stage can be identified by the presence of an enlarged or swollen area near the top of the main stem.

Factors Affecting Hay Quality

Stage of maturity at harvest is the most important factor affecting hay quality. As legumes and grasses advance from the vegetative stage to the reproductive (seed) stage, they become higher in fiber and lignin content and lower in protein content, digestibility, and acceptability to livestock. The optimal stages of maturity to harvest for high quality and long stand life of many hay crops are listed in Table 2-9. Making the first hay cut early permits aftermath growth to begin at a time when temperature and soil moisture are favorable for plant growth and generally increases total yield per acre. The effects of stage of harvest on hay quality and animal performance are shown in Tables 2-10 and 2-11. In both cases, early-cut hay resulted in better quality feed and superior animal performance.

Cutting tall fescue hay earlier can make a significant difference with growing cattle (Table 2-11). A Tennessee study measured the gains and feed efficiency of Holstein heifers fed three fescue hays cut May 3, May 14, and May 25. These dates corresponded to late boot/early head, early bloom, and early milk stage/seed forming, respectively. The latest cutting date, May 25, is still earlier than most fescue hay in Kentucky. Close analysis of the data in Table 2-11 reveals several key points (listed below). Taken together, these points strongly emphasize the value of cutting forages earlier, even tall fescue.

Table 2-10. The effect of alfalfa hay quality on performance of beef steers.[1]

	Good	Fair	Poor
Crude protein	18.7	15.9	13.7
Crude fiber	29.4	35.4	46.7
Animal performance			
Hay consumed, lb./day	17.1	16.5	13.8
Gain, lb./day	1.85	1.49	-0.06
Feed efficiency,			
lb hay/lb. gain	9.2	11.1	---

[1] 550-pound beef steers.
Source: A. S. Mohammed et al., 1967. Tennessee Farm and Home Science Progress Report 61. pp. 10-13. University of Tennessee Agricultural Experiment Station, Knoxville.

Table 2-11. Effect of stage of harvest of fescue hay on forage quality and animal gain.*

Stage of harvest	Date of cutting	Dry matter intake lb/day	Percent digestibility	Percent protein	Feed efficiency, lb hay fed per lb of gain	Yield, lb/acre	Gain, lb/ day
Late boot to head	May 3	13.0	68	13.8	10.1	1334	1.39
Early bloom stage	May 14	11.7	66	10.2	13.5	1838	0.97
Early milk stage—seed forming	May 25	8.6	56	7.6	22.5	2823	0.42

*Holstein heifers were used, average weight – 500 lb.
Source: University of Tennessee, reported in AGR-62: *Quality Hay Production*, University of Kentucky Cooperative Extension Service.

- The heifers ate more of the early cut hay, 13 lb./day compared to 11.7 and 8.6 for later cut hay.
- Early cut hay had the highest digestibility and crude protein. The drop in digestibility was small between May 3 and May 14, but much larger over the next 11-day period. Crude protein dropped about the same (about 3 percentage units) for each 11-day delay.
- Gain per day ranged from 1.39 to 0.42 lb./day for the three hays. The earliest cut hay supported the best gains, as expected. The decline in average daily gain was about the same for each 11-day delay in cutting.
- Maturity decreased gains per day more than forage digestibility. A delay of twenty-two days dropped digestibility by 17 percent (68 percent to 56 percent). Over this same period, daily gain dropped by 70 percent (1.39 to 0.42 lb./day). Small changes in quality made big differences in gain.
- The highest quality hay had the lowest yield per acre. Some argue that 500 to 1,500 lb. per acre is enough justification to delay cutting, and that may be true for mature cows with low needs.
- Curiously, gain per acre was almost equal for each of the three hays (yield per acre divided by lb. of hay per pound of gain), 132, 136, and 125 lb., respectively. If you calculate how long it would take to get that gain on each hay, you arrive at 95, 140 and 298 days respectively. Hay cut on May 25 could produce the same gain as hay cut on May 3 but it would take *twice* as much hay and *three* times as long.
- The May 3 treatment also has the added benefit of 22 extra days of forage growth compared to the May 25 hay field—extra growth that translates to a higher yielding, higher quality second cutting.

Curing and Handling Conditions

Poor weather and poor handling conditions lower hay quality. Rain can cause leaf loss and can leach nutrients from plants during curing. Sunlight can lower hay quality through bleaching and lower vitamin A content. Raking and/or tedding extremely dry hay can cause excessive leaf loss (Table 2-12). Raking and/or tedding while hay is moist (about 40 percent moisture) and baling before hay is too dry (below 15 percent moisture) helps reduce leaf losses.

Table 2-12. The effect of handling conditions on alfalfa hay losses.

	Raked and Baled Correctly (lb./A)	Losses			
		Raked Too Dry (lb./A)	Baled Too Dry (lb./A)	Raked and Baled Too Dry (lb./A)	Total Percent
Dry hay	2,900	700	100	1,000	34
Crude protein	660	210	60	290	44
T.D.N.	1,710	480	90	690	40

Source: Alfalfa Hay Quality. D. Ball, T. Johnson, G. Lacefield, and H. White. Special Publication. Certified Alfalfa Seed Council. Davis, Calif.

Freshly harvested hay averages 80 percent moisture content and therefore must lose about 6,000 pounds of water to produce a ton of hay at 20 percent moisture. Crushing stems (conditioning) at time of mowing causes stems to dry at nearly the same rate as leaves. Conditioning decreases the drying time of larger-stemmed plants alfalfa, red clover, and warm season annuals by approximately one day and can improve leaf retention and forage quality.

Figure 2-30. Making haylage by wrapping high moisture round bales in UV-resistant stretch wrap allows the harvest of quality forage and helps avoid rain damage.

Legumes and Hay Quality

Incorporating legumes into hayfields will increase forage quality. When grasses and legumes are harvested at the proper stage of maturity, legumes are usually higher in total digestibility, rate of digestion, protein, and many minerals and vitamins. Legumes can improve summer growth and add N to the system through biological N fixation in their root nodules. A mixture consisting of an adapted grass and legume is usually of high quality when properly managed. Grasses will improve the drying rates of mixed stands compared those which are mostly legumes.

Producing Round Bale Haylage

The ability to harvest moist forage as haylage gives Kentucky producers many advantages, including timely harvest, higher forage quality, and less weathering loss over hay systems. The baleage system allows producers to utilize commonly available forage equipment (mowers, rakes, balers) rather than requiring choppers and silo structures or bags (Figure 2-30).

To better understand the quality of haylage in Kentucky, samples of a variety of types of haylage were collected in 2017-18 and analyzed for forage quality and fermentation profile (pH and volatile fatty acid content). The survey identified the following important considerations for making high quality haylage.

- Cut at the proper stage of maturity. The fermentation process is driven by the soluble carbohydrates present at cutting. Early cut forage has greater carbohydrates. All forages, cut at boot to early head (for grasses) and bud to early bloom for legumes will ensile.
- Bale when the wilted forage is between 40 percent and 60 percent moisture content (MC). In this survey, only excessively wet (80 percent MC, essentially unwilted) forage had an 'off' fermentation profile with excessive butyric acid.
- Bales should be as tight as possible to help exclude oxygen and accelerate the ensiling process.
- Wrap moist hay the day of baling. Delaying to the next day allows heating to begin.
- Wrap bales with six to eight layers of UV-stabilized, stretch wrap plastic.

Early work indicated that as few as four layers could be effective. However, top producers use six or more layers. In addition, UK research has seen clear feeding preferences for bales with at least six layers of coverage.

- Periodically check the wrapped bales and plug any holes present in the bales with special UV-stabilized tape.
- The ensiling process is complete within six to eight weeks, but bales may be fed at any time after wrapping. Bales that have not completely fermented will spoil quickly when exposed to air.

Evaluating Forage Quality

Forage testing is the most practical way to determine the nutrient content of hay. Each lot of hay should be tested by taking a representative core sample from 15 to 20 bales using a forage probe (Figure 2-31). A lot is a group of hay that has been cut, baled and stored similarly. Once taken, analyze the sample for quality through a reputable laboratory such as those certified by the National Forage Testing Association. Use the quality report information to match hay to different classes of livestock and supplement accordingly.

Feeding Decisions for the Cow Herd – The UK Beef Cow Forage Supplement Tool

Wintering cost is the largest single expense for beef cow-calf producers. Manage this cost by making sound supplementation and hay feeding decisions using the UK Beef Cow Forage Supplement Tool (Figure 2-32). The UK Beef Cow Forage Supplement Tool is a simple web-based tool to estimate forage intake and supplementation rates.

To use the tool, producers need to know the quality of the hay to be fed (dry matter, protein, NDF and TDN) and the desired stage of production of the cows (cow size is fixed at 1,250 pounds). Once the forage and cow production stage is entered, producers choose from among several commonly available supplement options and the program calculates the amount to be fed to balance the forage.

The program was developed by beef specialists in the UK Department of Animal and Food Sciences and is designed to provide quick and simple feeding solutions for Kentucky producers. Remember that many variables such as weather conditions, body condition, animal health, and palatability of feedstuffs can affect actual intake and animal response to a feeding program. Actual feed/forage intake and body condition should be monitored throughout the feeding program. Cattle should also have access to a complete mineral supplement and clean drinking water at all times.

Figure 2-31. A representative hay sample is a composite of cores from 15 to 20 bales in a lot of hay.

Figure 2-32. The UK Beef Cow Forage Supplement Tool gives quick feeding solutions for available hay choices based on a current forage analysis, cow size, and stage of production.

Hay Storage and Feeding Options

Most of the hay produced in Kentucky for feeding livestock is packaged as large round bales. Much of this hay is stored outside without protection from weather. Losses during outside storage of twine-tied round bales result from weathering and from moisture movement from the ground into the bale. Weathering is visually associated with a change in color and deterioration of the outer layers of hay following exposure to rainfall, sunlight, and other factors during storage. Weathered hay suffers substantial losses of both yield and forage quality and is much less palatable to livestock than undamaged hay.

Research has shown that twine-tied round bales stored outside and in direct contact with the ground can lose 25 percent to 35 percent of their dry matter. Net wrap reduces this DM loss to 15 percent to 25 percent. Breaking contact with the ground can reduce storage losses to 13 percent to 17 percent. Breathable hay wrap (B-wrap®) is being marketed with claims to allow moisture to leave the bale but prevent water penetration from soil or weather. Feeding studies have shown that B-wrap® stored outside has feed characteristics similar to barn-stored hay.

Inside storage is best for round bales, with many designs and options available. Many producers have added tarp-covered hoop structures for on-farm hay storage. Barn storage reduces DM losses to 4 percent to 7 percent (Figure 2-33).

Kentucky producers have many options for hay feeding, including ring feeders, unrolling, bale grazing, in-line fence feeders and of course, just setting out round bales (Figure 2-34). When using ring feeders, those with solid sheeting at the

Figure 2-33. Tarp-covered hoop structures provide cost-effective hay storage in Kentucky.

bottom reduce hay losses by 15 percent to 20 percent compared to those with just bars because cattle cannot pull hay from the ring as easily. Hay unrolling can be desirable to spread out hoof damage and provide better distribution of manure and urine in feeding areas. Finally, bale grazing is gaining in popularity and usage in some situations. With this system, bales are placed on a field before the feeding season and allocated by moving temporary electric fence. This system has the advantage of reducing tractor tire damage as well as good nutrient distribution.

Figure 2-34. The type of round bale feeder matters. Using round bale feeders with solid sheeting at the bottom can reduce hay losses by 15 to 20 percent.

Summary

Forages provide the majority of nutrients for beef cattle in Kentucky. Kentucky's land and climate are well suited for the production of cool-season perennial grasses and legumes. Forages are significant in every county in Kentucky. The most common perennial grass is tall fescue, and 80 percent or more of the fescue present in pastures is infected with the toxic endophyte of tall fescue. Cattle producers can be effective managers of forages by developing a plan to manage the endophyte of tall fescue, implementing a planned rotational grazing system and focusing on efficient harvest and feeding of stored forage.

Environmental Compliance for Kentucky Beef Operations

Steve Higgins, Lee Moser, and Kylie Schmidt

Environmental compliance is typically a sensitive subject among livestock producers. The fear of adapting to environmental regulation is often a result of perceived costs, expectations that production will be limited, resistance to change, and a general lack of information. Environmental compliance topics are often addressed through simple production practices. Practices such as rotational grazing have been highlighted for production benefits, although there is an equal amount of environmental benefit. Practices that accomplish both production and environmental benefits are called best management practices (BMPs). BMPs can no longer be ignored. Some are required by law, although adoption rates are generally low. Research shows that voluntary compliance leads to less environmental regulation, so it is best to achieve compliance now in order to maintain flexibility. Regulators are not the only ones concerned about how the farm is managed—consumers have become equally influential in the way food is grown or raised. Most producers desire to manage their cattle operations in a manner that prevents soil erosion and sustains water quality. This chapter of the beef book is for producers who want to preserve their farm, achieve their production potential, and obtain a market advantage.

What are You Required to Do?

In Kentucky, beef cattle producers are required by law to have an Agriculture Water Quality Plan (AWQP) (https://www.uky.edu/bae/sites/www.uky.edu.bae/files/KAWQ_Plan.pdf). An AWQP is a list of planned and implemented best management practices (BMPs) that covers six areas of the operation: farmsteads, crops, livestock, pesticides and fertilizers, streams and other water bodies, and forestry. To help complete the plan, an online or hardcopy workbook asks a series of questions to help identify where BMPs may be needed and then offers a list of suggested BMPs. Producers may offset the cost of implementing BMPs by using local, state, or federal cost share programs. The tool to help producers develop an AWQP can be accessed at: https://www.uky.edu/bae/sites/www.uky.edu.bae/files/awqp.pdf. Contact the local Cooperative Extension office or Conservation District for more information or for assistance completing the plan.

As part of the AWQP, livestock producers are also required by law to have a nutrient management plan. There are several options for developing nutrient management plans. A Comprehensive Nutrient Management Plan (CNMP) is required for producers requesting cost share or technical assistance from Conservation Districts or the Natural Resources Conservation Service (NRCS) for manure handling systems. A CNMP must be completed by a Technical Service Provider (TSP) certified by the NRCS. Cost share is available to offset the cost of developing a CNMP. Producers not needing a CNMP must implement a Kentucky Nutrient Management Plan (KyNMP), outlined in the University of Kentucky Cooperative Extension (UKCES) publication ID-211: *Kentucky Nutrient Management Planning Guidelines* (http://www2.ca.uky.edu/agcomm/pubs/id/id211/id211.pdf). In some cases, a TSP may be willing to write a KyNMP for a nominal fee. Your local Conservation District or Cooperative Extension agent may be able to assist with the completion of a KyNMP. Producers can also write their own plan by reading ID-211: *Kentucky Nutrient Management Planning Guidelines* and using the resources provided at https://www.uky.edu/bae/awqp-nmp.

What You Should Do

Simply having an Agriculture Water Quality Plan (AWQP) does not ensure compliance, as the operation may still be contaminating water resources. The goal is to prevent contamination—not just have a piece of paper. The AWQP workbook is intended to help producers choose a suite of best management practices (BMPs) that collectively prevent nutrient and soil laden runoff from leaving the farm. It is up to the producer to choose and implement which BMPs work for their operation to achieve this goal. Since it may not be feasible to implement all the necessary BMPs at once, the planned BMP component of the AWQP shows an inspector that the producer is aware of the issues and has a long-term plan for mitigating them. In other words, there is a lot of flexibility and forgiveness with the AWQP; however, if voluntary compliance is not improved, then more BMPs will likely become required. Essentially, an AWQP is a farm planning tool to get the producer to start thinking holistically about the operation. Therefore, producers should carefully complete the AWQP workbook and consult with technical professionals to choose which BMPs are right for their operation and develop an action plan for implementing the BMPs.

Best Management Practices for Beef Operations

From an environmental perspective, best management practices (BMPs) are designed to prevent soil, nutrients, pathogens, and other water quality contaminants from leaving the farm. From a production perspective, the goals of BMPs are to effectively manage mud, manure, and runoff. The following BMPs are organized by their intended focus of managing mud, manure, or runoff; many of them help manage all three. Use the

following as a guide for choosing which suite of BMPs work for a given operation.

Managing Mud

Some producers may think that mud is an inevitable part of livestock production. Mud can limit production potential by decreasing performance. Livestock that walk through and lay in mud expend more energy and thus require more feed to reach a desired weight. In addition, if livestock must walk through mud to obtain feed or water, they will not eat as often because of the increased walking effort. In a muddy lot, livestock tend to stand because there is not a dry place to lie. Standing requires more energy than lying, and mud accumulation on the hair can affect production by increasing the amount of energy needed to regulate body temperature. Mud and manure in the hair coat can also lower sale prices. Mud can increase animal stress and lead to a variety of health problems and even death. Feeding in muddy areas, such as in a typical winter feeding area, also results in wasted feed. The bottom line is mud costs producers money. Below are several BMPs that help prevent mud and provide many other production benefits.

Planned Grazing System

Rotational grazing and stockpiling forages are planned grazing systems. Rotational grazing is an excellent practice for controlling mud, but it also benefits producers during a drought. Planned grazing reduces mud by dividing larger pastures into smaller pastures that can be alternately rested and grazed, as this helps maintain optimal vegetative cover. A well planned grazing system also provides strategically located water, minimizes damage to trees and stream banks, provides shade and windbreaks, and minimizes lanes (discussed later). Rotational grazing provides a multitude of other production benefits such as reduced supplemental feeding and pasture waste, improved forage composition, and increased stocking densities compared to continuously grazed systems. Stockpiling forages rests a pasture during the end of the growing season until it can be incrementally grazed in the fall or winter. Providing livestock access to the stockpiled pasture incrementally prevents spot grazing and soiled forage. This BMP is relevant to producers who have overgrazed pastures, pastures with suboptimal forage quality, and pastures with excess mud from high stocking rates. To learn about the other benefits of rotational grazing and how to develop a rotational grazing plan, see the UKCES publication ID-143: *Rotational Grazing* (http://www2.ca.uky.edu/agcomm/pubs/id/id143/id143.pdf) and AGR-162: *Stockpiling for Fall and Winter Pasture* (http://www2.ca.uky.edu/agcomm/pubs/agr/agr162/agr162.pdf).

Stocking Density

Whether using a rotational or a continuous grazing system, an appropriate stocking density is necessary to maintain adequate vegetative forage, which helps prevent the creation of mud and erosion and reduces stored feed needs. In order to maintain an appropriate level of cover, stocking densities may need to be reduced. A publication has been developed to assist producers in estimating the carrying capacity and proper stocking density of their cool-season pastures in Kentucky through the use of Web Soil Survey, available at http://www2.ca.uky.edu/agcomm/pubs/AGR/AGR222/AGR222.pdf. The overstocking of pastures may temporarily support an increased herd, but soil loss can lead to reduced plant persistence and subsequent soil loss, which can increase labor and fuel costs. Overstocked pastures can also become a compliance concern because denuded (i.e. no vegetation) lots act as an impervious surface and generate nutrient rich runoff. If stocking densities cannot be reduced or if it is not feasible to rehabilitate a denuded lot, the operation should consider switching to confinement or installing an all-weather surface in the lot surrounded with vegetative buffers to avoid compliance violations. An all-weather surface would facilitate manure collection, thus reducing the potential for runoff and contamination of nearby water resources.

Alternative Water Sources with All-weather Surfaces

Watering points are a critical component of any grazing system since water intake encourages feed intake and watering point locations determine grazing efficiency as well as manure and urine distribution. However, providing water alone is not sufficient—water quality is equally important as water quantity. Although natural water sources are an inexpensive alternative to other watering systems, when they become contaminated they can limit production and lead to multiple health problems. Over the last few years, blue-green algae blooms have become more prevalent in lakes and ponds. These potentially harmful algae blooms have shut down public water supplies and killed cattle. Producers should not assume that their ponds or creeks are free of blue-green algae or other contaminants. Research has shown that beef cattle production can be significantly increased when livestock have access to clean water. Because of this, livestock should be excluded from contaminated surface waters and provided with an alternative water source surrounded with an all-weather surface. To learn how to site and construct an all-weather surface for an alternative water source, see the UKCES publication ID-229: *All-weather Surfaces for Cattle Watering Facilities* (http://www2.ca.uky.edu/agcomm/pubs/ID/ID229/ID229.pdf). An alternative water source is a water supply other than natural water bodies with unlimited access. Alternative water sources may include water harvested from roofs, a developed spring, pipeline and tank, a gravity-fed tank below an excluded pond, or an automatic watering fountain supplied with city water. Figure 3-1 shows how a pond can be fenced off and still provide clean drinking water to a gravity-fed stock tank.

The vegetated area surrounding the pond serves as a filter strip can also be flash-grazed periodically. Frequent use of the alternative water source and loitering creates surface depressions filled with mud, manure, and urine, which expose pipelines to freezing temperatures and can cause a variety of livestock health issues (Figure 3-2). An all-weather surface prevents surface depressions and protects livestock health. Consider installing alternative water sources in lanes or in a layout such as in Figure 3-3, so it can be used to service multiple pastures in conjunction with a rotational grazing system. Additional information related to providing alternative water sources in beef cattle production systems is available for download at http://www2.ca.uky.edu/agcomm/pubs/ID/ID236/ID236.pdf.

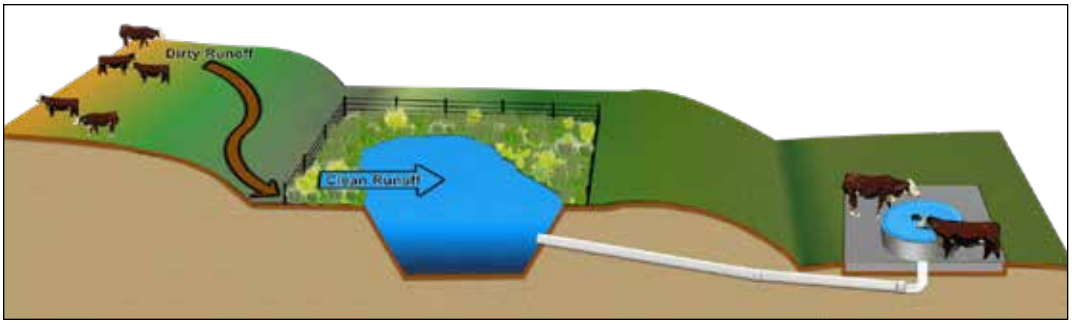

Figure 3-1. With a gravity-fed system, livestock can be excluded from ponds to prevent contamination and still be provided with clean water. Figure by Donnie Stamper

All-weather Surfaces

Watering points are just one of several heavy-use areas on the farm that are prone to mud and erosion, even with an appropriate stocking density. The foot pressure of standing cattle is approximately 69 percent greater than a 50-ton bulldozer. Other typical heavy-use areas include feeding lanes, winter feeding areas, and gate entrances. These areas should be reinforced with an all-weather surface such as concrete or geotextile fabric and rock. Consider turning sacrifice lots into dry lots, which are much more versatile, by installing an all-weather surface. To prevent runoff contamination, manure should be routinely collected from all-weather surfaces. However, scraping can remove rock, so it will need to be replaced periodically. If an area is to be routinely scraped, then concrete should be considered.

Figure 3-2. Without an all-weather surface, the heavy use area has eroded to the point where the watering facility is almost inaccessible and is no longer frost-proof. The depression also poses a threat to livestock health because livestock have to stand in mud and excrement to drink. Note the diameter of the bare soil area (18′). Photo by Jeff Lehmkuhler

Hardening heavily used livestock areas can decrease the creation of mud, create an area that is easier to maintain, reduce the amount of feed wasted and required by livestock, and save time and money by increasing work efficiency. Feeding and heavy-use areas should be protected with an all-weather surface such as concrete or geotextile fabric and rock. Figure 3-4 shows an all-weather surface used for fence-line feeding with roll bales, demonstrating how all-weather surfaces can be used in conjunction with certain management styles. To learn about all-weather surface options and how to install them, see the UKCES publication AEN-115: *All-Weather Surfaces for Livestock* that is available for download at (http://www2.ca.uky.edu/agcomm/pubs/aen/aen115/aen115.pdf).

Stream Crossings

Drainages or streams that have flowing water for more than 30 days per year (total) should be excluded from livestock. If livestock have access to flowing drainages, there is an increased chance of a water quality violation, and as previously mentioned, this water is likely hindering cattle performance. When planning a grazing system, livestock should be excluded

Figure 3-3. Alternative water sources can be constructed to service multiple pastures in conjunction with a rotational grazing system, such as in this layout. Figure by Donnie Stamper

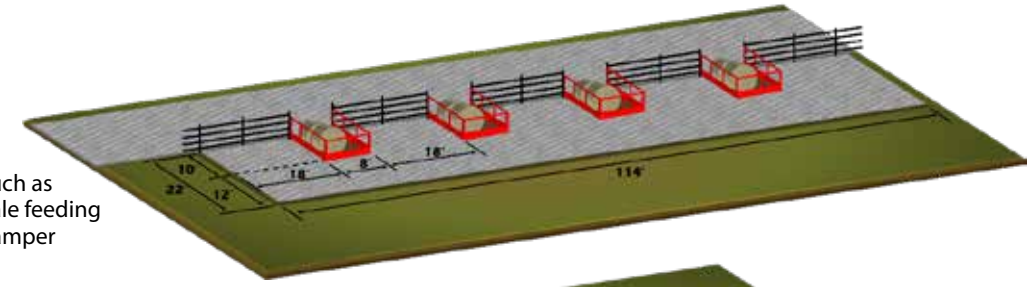

Figure 3-4. All-weather surfaces can be used to fit any management style, such as with this fence line, roll bale feeding lane. Figure by Donnie Stamper

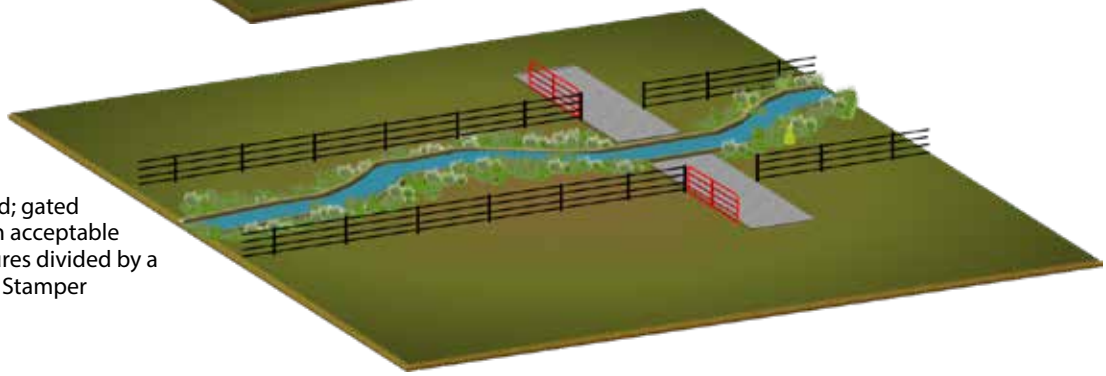

Figure 3-5. Livestock should be excluded from drainages and a vegetated buffer should be established; gated stream crossings provide an acceptable method for accessing pastures divided by a drainage. Figure by Donnie Stamper

from drainages. If a drainage (e.g. stream) must be crossed to access other pastures, stream crossings should be installed. A stream crossing is an acceptable method for moving livestock to pastures separated by water, whereas unrestricted stream access is unacceptable. Stream crossings should consist of a reinforced surface to prevent erosion and gates on each side of the stream to restrict access when the crossing is not being used (Figure 3-5). To learn how to site and install a stream crossing, see the UKCES publication AEN-101: *Stream Crossings for Cattle* (http://www2.ca.uky.edu/agcomm/pubs/aen/aen101/aen101.pdf).

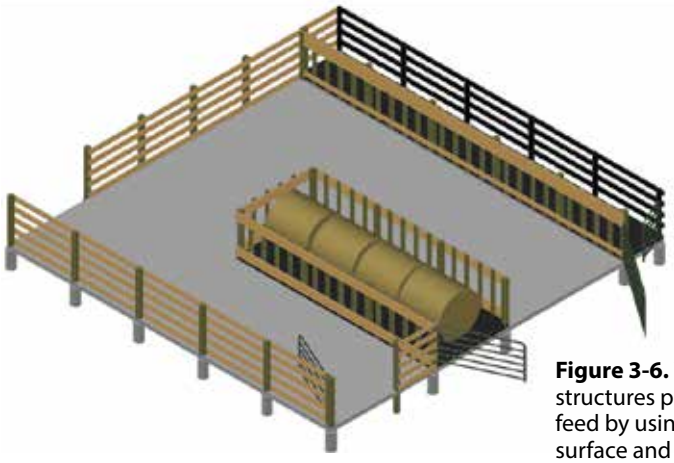

Figure 3-6. Winter feeding structures prevent mud and save feed by using an all-weather surface and an elevated feed rack. Figure by Donnie Stamper

Winter-feeding Structures

A winter feeding structure is an area with an all-weather surface that includes geotextile fabric and rock and/or concrete surfaces. Figure 3-6 shows a winter feeding structure that is ideal for winter feeding cattle within a rotational grazing system rotational grazing. This system should be installed using a holistic approach where beef feeding and handling are centered on this structure. An ideal situation uses lanes, multiple pastures, and pens with the structure being centrally located and near hay storage. Water sources should be located at least 150 feet from the structure to reduce the volume of manure that needs to be handled. This practice allows limit feeding in which cattle come to the structure for feeding during the winter or during wet weather and then return to a vegetated pasture for water. Additional areas or pens can be set up to facilitate creep feeding or creep grazing. Several cattle herds can be managed at once using this type of system. The system is designed to elevate hay and feed and keep cattle from wasting hay. This structure protects pastures, decreases livestock energy expenditures (as opposed to walking through mud), facilitates manure collection, and reduces labor, expenses, and wasted feed. For more information on winter feeding structures, see the UKCES publication ID-188: *Strategic Winter Feeding of Cattle using a Rotational Grazing Structure* (http://www2.ca.uky.edu/agcomm/pubs/id/id188/id188.pdf).

An additional winter feeding system has been developed through the fence-line feeder project at Eden Shale Farm. Details on how to build and incorporate a fence-line feeding system into your operation can be found at: http://www2.ca.uky.edu/agcomm/pubs/AEN/AEN134/AEN134.pdf.

Managing Manure

Manure plays an essential role in farm production as an on-farm source of nutrients and organic matter. In order for manure to be an effective fertilizer and soil amendment to lower input costs, it must be properly collected, stored, and managed. Improperly collecting and storing manure could lead to nutrient losses. Nutrient losses increase spending, decreased yields, and increase wasted time and money by applying a low nutrient value product. Conversely, some producers may be over applying manures

to fields. Proper collection and utilization of manures and deceased animals also prevents pathogens from entering water resources and thus protects overall herd health. The following best management practices (BMPs) discuss how to properly collect and utilize manure and handle animal mortalities.

Manure Management System

With today's regulatory climate, it is critical that producers have a manure management system. A manure management system is a combination of BMPs used to collect and store manure and a plan for how nutrients will be utilized without degrading water resources. Components of a manure management system include, but are not limited to: manure storage structures, manure handling, and a nutrient management plan.

Ideally, a beef producer should limit the concentration of animals to reduce the labor involved with manure buildup and cleanup. This is why rotational grazing is such a good management tool; it allows the cattle to distribute manure evenly over a field. However, winter feeding necessitates the concentration of animals. In the past, there have been cost-share opportunities to build covered manure stack pads and adjacent feeding structures. Obtaining a manure stack pad through state or federal cost-share today requires a Comprehensive Nutrient Management Plan (CNMP).

In some cases, there have been dairies that have switched over to beef production. These farms may have a manure storage pond or lagoon, which would require a Kentucky No Discharge Operational Permit (KNDOP) from the Kentucky Division of Water and may need to close out their structure. For more information on closing out a liquid manure holding structure see the UKCES publication AEN-125: *Closing a Liquid Manure Storage Structure,* which is available as a free download from http://www2.ca.uky.edu/agcomm/pubs/AEN/AEN125/AEN125.pdf.

Manure Storage Structure

If manure is exposed to precipitation, sunlight, or wind, the amount of plant available nitrogen will decrease due to volatilization, leaching, and runoff, making the manure less valuable as a fertilizer. To minimize nutrient loss and comply with state law, manure should be collected from impervious surfaces and stored in a manure storage structure. A manure storage structure, also known as a stack pad, is a roofed structure that is used for storing solid manure. Managing manure as a solid, as opposed to a liquid, has many benefits:

- A manure storage structure allows it to dry out and compost.
- A manure storage structure can be used for dead animal composting.
- Solid manure is cheaper to haul off-site.
- Solid manure retains higher nutrient content, requiring a reduced application rate.
- Solid manure is less likely to be transported with runoff after land application.
- A manure storage structure is less problematic and requires less management than liquid manures.
- Running equipment for scraping and land-applying is cheaper than running equipment for pumping and injecting.

Nutrient Management Planning (NMP)

This BMP involves managing all sources of nutrients on the farm, such as manure, mortalities, inorganic fertilizer, crop residues, and legume crops. From a compliance and production standpoint, it is likely the most important BMP to implement.

Nutrient management planning is an extensive topic, but below are some key components of proper nutrient management:

- Manure should be applied to soils based on existing soil fertility and realistic yield goals. The primary soil nutrient that should be monitored is the soil test phosphorus (STP) concentration. Producers will not get a yield benefit by applying manure to soils above 45 pounds of STP per acre.
- Collect manure from impervious surfaces and store in a proper storage structure.
- Prevent manure deposited on pastures or holding areas from entering water resources.
- Collect soil and manure samples prior to land application and use a NMP to determine application rates.
- Only apply manure to actively growing plants or just before planting.
- Never apply manure to frozen ground. Manure applied in winter is likely to be washed into streams instead of being absorbed in the soil.
- Never apply manure within 24 hours of a rainfall event, as this too can result in nutrients leaving the application area.
- When possible, incorporate manure in the soil immediately after application.
- Never apply manure near environmentally and socially sensitive areas such as surface waters (streams, ponds, wetlands, etc.), sinkholes, or roads.

Disposal and Composting of Animal Mortalities

Acceptable methods for dead animal disposal in Kentucky are incineration, burial, removal by a licensed rendering company, disposal in an approved landfill, and composting. Composting is the easiest and most cost-effective option; however, if a pickup service is available at minimal or no cost, it may be used instead. Whichever acceptable method (by law) is used, it must be accomplished within 48 hours of the animal's death.

A mortality composting facility should be located near animal housing. The composting area should not be built in a floodplain, within 300 feet of a water well, stream, sinkhole, pond, property line, or public road, or within 1,500 feet of churches, schools, businesses, or any other public use area. When choosing a site, consider that any runoff lost from the compost pile should be diverted to an existing manure storage structure or to a vegetated filter strip. The leading edge of the filter strip and the low edge of the composting pad must be level, and the filter strip must be at least 30 feet long. The filter strip vegetation must be maintained as specified in the NRCS filter strip standard. In addition, if the composting structure is located within a pasture, fencing is required to exclude livestock from both the composting pad and the filter strip.

The type of composting structure used should be based on the type and size of the animal operation. Ideally, the structure should have a concrete pad, sides to facilitate loading and turning, and a roof to block precipitation. A roof and sides are not required, but for operations with more than 100 animal units, the pad flooring shall be constructed

using a "High Traffic Area" surface such as concrete, soil cement, sound bedrock, compacted clay, or heavy traffic pads using rock and geotextile fabric. All of these surface treatments prevent mud creation and reduce sediment in runoff. For more information about soil cement, see UK Cooperative Extension publication ID-176: *Using Soil-Cement on Horse and Livestock Farms* (http://www2.ca.uky.edu/agcomm/pubs/id/id176/id176.pdf). To construct a heavy traffic pad as a composting surface, refer to UK Cooperative Extension publication ID-164: *High Traffic Area Pads for Horses* (http://www2.ca.uky.edu/agcomm/pubs/id/id164/id164.pdf). For operations with less than 100 animal units, composting can be conducted directly on the soil as long as the composting site is alternated with a crop rotation. You can use traditional composting facilities like stack pads, bins, windrows, and vessels; however, a windrow system, using an uncovered stack pad made with a High Traffic Area surface is by far the easiest structure to manage and the cheapest to construct for composting large animals.

To learn more about how to compost animal mortalities, see the UKCES publication ID-166: *On-farm Composting of Animal Mortalities* (http://www2.ca.uky.edu/agcomm/pubs/id/id166/id166.pdf).

Managing Runoff

Managing runoff is about keeping clean water clean and collecting or filtering contaminated water. From a production perspective, these BMPs prevent mud and erosion. Stormwater can also be harvested to provide the operation with a free source of water. For example, stormwater could be directed toward a farm pond that gravity feeds an alternative water source or could be collected from facility roofs and stored in tanks to directly water livestock. If the operation uses a liquid manure storage pond, managing stormwater can effectively add capacity to the pond by diverting clean water away from the liquid manure handling structure. Properly collecting or treating contaminated runoff can also help protect livestock health by minimizing the risk of consumption and prevent compliance violations.

Stormwater Diversion

Stormwater diversion is the practice of diverting uncontaminated rainfall away from production areas so it does not encounter manure, soil particles, fertilizers, pesticides, or other water quality contaminants. Areas that typically have clean stormwater on farming operations are properly stocked pastures, facility roofs, roads, or other surfaces that do not contain a high concentration of contaminants. Clean stormwater should be diverted away from contaminants to designated drainages with gutters, pipes, grassed waterways, or ditches to reduce the amount of contaminated water that needs to be managed. Once stormwater encounters water quality contaminants, it needs to be properly collected or naturally filtered depending on the level of contamination. Frequent manure collection from impervious surfaces such as feeding lanes and confinement areas will also help minimize the amount of water that needs to be managed. Stormwater BMPs must be considered on a site-specific basis. The following are a few examples of stormwater BMPs:

Gutters. If a facility has a roof that drains onto a production area, consider installing gutters with downspouts. Placing gutters on buildings diverts clean rainwater away from animal handling and holding areas and prevents the contamination of this otherwise clean and usable water. Downspouts should be directed to diversion ditches, and guttered water should be carried away from animal containment areas.

Headwater diversion. Over time, topography can be altered with road creation, structure remodeling, and facility additions, causing runoff to flow through the production area. To keep clean runoff clean, diversion practices should be implemented if water enters the production facility from upland sources, such as drainages or overland flow. Headwater diversion entails installation of structures such as levees, dikes, drainage swales, berms, and diversion ditches to carry the water away from the production area and to a natural drainage way.

Gully erosion structures. One way to fix gully erosion is with a grade stabilization structure or other hardened structures (e.g. rock chutes, check dams, etc.). Hardened structures such as these use large rock-lined ditches, posts, fabric, and fence panels to slow flowing water and prevent erosion. To learn how to install a grade stabilization structure, see the UKCES publication AEN-100: *Building a Grade Stabilization Structure to Control Erosion*, which is available for download at http://www2.ca.uky.edu/agcomm/pubs/aen/aen100/aen100.pdf. Ways to prevent gully erosion include: controlling stocking density, regulating time in a field, and by fencing off drainages.

Culverts. Culverts are an essential component of stormwater diversion, as they help quickly transport runoff away from the operation. If a culvert that is too small for the drainage area is installed, water may flood on the upstream side of the culvert and severe erosion can occur on the downstream side. Consult a technical service provider to ensure culverts are properly sized. Installing a culvert, in some cases, may require a floodplain construction permit from the Division of Water (http://water.ky.gov/floodplain/Pages/FloodplainConstruction.aspx).

Vegetative Buffers

Vegetative buffers are a set of practices that utilize vegetation to filter and trap sediment, pathogens, and other water quality contaminants. In some cases, contaminated runoff can be sufficiently treated with vegetative buffers, such as a riparian buffer, filter strip, or grassed waterway to avoid regulatory issues and nuisance driven complaints. The key to a successful vegetative buffer is to maintain sufficient forage growth to slow, trap, and filter runoff before it leaves the farm. The size of a vegetative buffer depends on the volume of runoff and level of contamination, but aim for the maximum size possible to ensure water quality compliance. The following are a few examples of vegetative buffer BMPs.

Riparian buffer. Riparian buffers, also called streamside buffers, can be created passively (naturally) or actively. Passively creating a riparian buffer is as simple as establishing a no-mow zone around a stream or pond and allowing vegetation to reestablish itself naturally. This method is an easy and inexpensive way to create a riparian buffer, but may require maintenance to prevent the growth of unwanted invasive plants. A typical rule of thumb

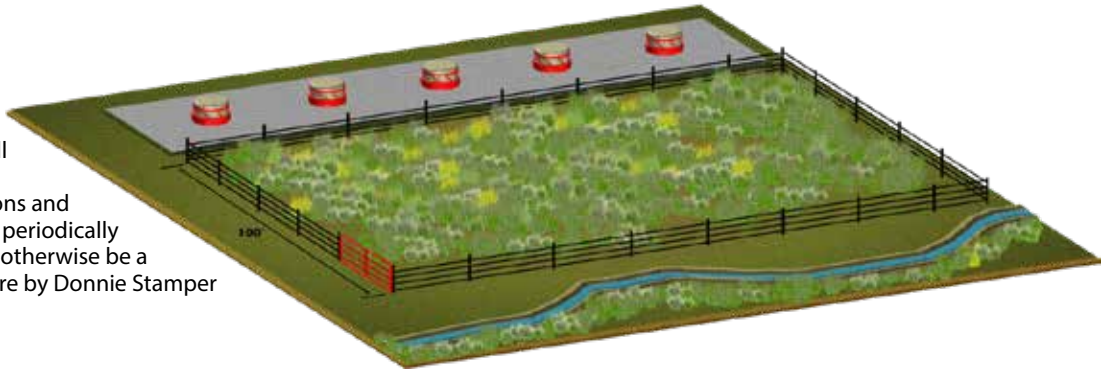

Figure 3-7. Filter strips can be used on the downhill side of production areas to prevent compliance violations and provide an area that can be periodically flash-grazed in what would otherwise be a denuded, muddy area. Figure by Donnie Stamper

is to create a buffer that is three times the width of the creek. If the floodplain is known, then the buffer should extend outside of this area. Creating a buffer does not necessarily mean that the area is lost to production. Many areas can be flash-grazed during dry periods. These corridors can be used to move cattle from one pasture to another to facilitate rotational grazing. For more information on riparian buffers, see the UKCES publication ID-175: *Riparian Buffers: A Livestock Best Management Practice for Protecting Water Quality*, which is available for download at http://www2.ca.uky.edu/agcomm/pubs/id/id175/id175.pdf.

Filter strips. Filter strips should be placed on the downhill side of production areas to provide a buffer for filtering runoff and preventing erosion. The filter can be established by installing a fence around a 100-foot wide filter strip that is the length of the production area. The filter strip in Figure 3-7 can be periodically flash-grazed, and the filter strip in Figure 3-8 can be used as a creep feeding pasture for calves. Depending on its use, filter strips should be planted with dense grass sod consisting of forages designed to be actively growing during times when cattle are confined to the feeding area. Novel endophyte tall fescue makes an excellent filter strip in Kentucky because of its superb growth, adaptability, nutrient uptake, and safety for livestock. Filter strips should also be managed so that vegetation is periodically removed or flash-grazed to continue nutrient removal, prevent unwanted brush growth, and keep the soil test phosphorus levels from becoming too high. To learn more about filter strips, see the UKCES publication ID-189: *Enhanced Vegetative Strips for Livestock Facilities*, which is available at: https://www.uky.edu/bae/sites/www.uky.edu.bae/files/id189.pdf.

Grassed waterways. Grassed waterways are gently sloped stormwater diversion ditches that are lined in grass or other suitable vegetation. Grassed waterways help convey, slow, and filter stormwater. Grassed waterways should only convey clean water, as their main purpose is to prevent erosion. If vegetation is not maintained, head-cutting or gully erosion may occur.

Shade Structures and Windbreaks

Shade structures and windbreaks can reduce cattle energy expenditures by protecting them from the hot summer sun and brutal winter winds. The concept behind providing shade for livestock is to lure them away from drainages, streams, and other areas where tree canopies typically provide shade. Livestock tend to loaf in these areas, consequently creating mud and nutrient buildup.

Producers should consider using portable shade sleds to provide shade without creating mud and environmental problems. Shade structures can be constructed so they can easily be moved within and among pastures as part of a planned grazing system. The ability to move these structures facilitates manure cleanup and reduces soil compaction and mud. A permanent shade structure with an all-weather surface could also be used. An ideal shade structure for cattle provides 20 square feet of shade per animal. A 70 percent or greater occluded shade cloth can be used as the shade material. This same material can be used to drape the southern or western sides to provide additional shade and act as a windbreak for southern prevailing winds. To learn more about shade structures, see the UKCES publication AEN-99: *Shade Options for Grazing Cattle* (http://www2.ca.uky.edu/agcomm/pubs/aen/aen99/aen99.pdf).

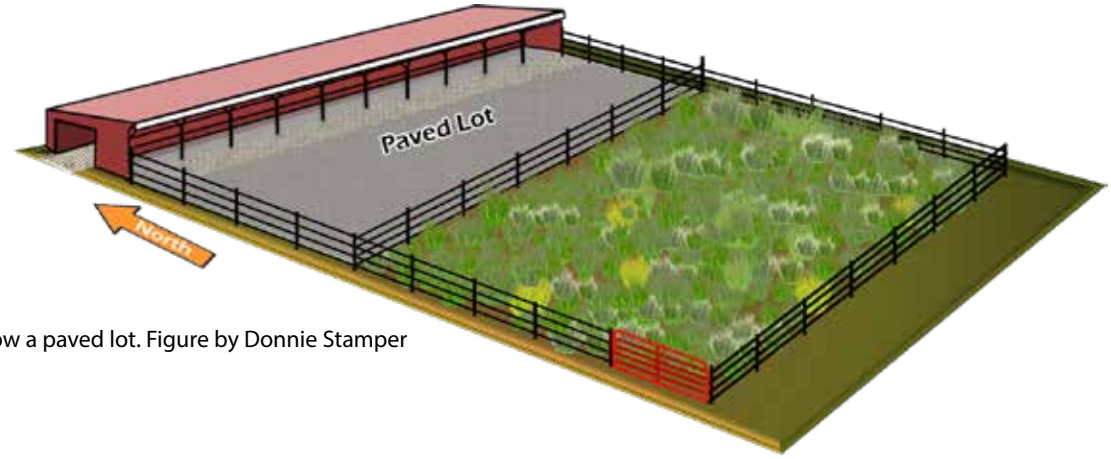

Figure 3-8. Filter strips below a paved lot. Figure by Donnie Stamper

Windbreaks can be provided by vegetation or materials on the farm that cannot be destroyed by the animal. The height of the windbreak only needs to be as tall as the animal. The windbreak should be oriented along the east-west axis and set away from fence lines to allow livestock to have access to each side of the windbreak. Some common farm materials that can be used to create a windbreak include trees, shrubs, plywood, metal siding, and round bales.

Summary

Best management practices (BMPs) are research-proven methods for farm management that provide numerous production benefits to the producer while helping to protect natural resources. Production benefits include: increased weight gains and work efficiency, improved marketability and animal well-being, and reduced spending on fertilizer, feed, fuel, water, and labor. Although many innovative BMPs have been developed that incorporate recent findings and technology, the majority of BMPs advocated today have been advocated since the 1930s, yet there is still a lack of voluntary adoption and thus a depletion of natural resources. To prevent a continued depletion, regulations now require that certain BMPs be implemented. Cost-share and technical assistance is available to assist producers with implementing their Agriculture Water Quality Plan through the Natural Resources Conservation Service, their local Conservation District, or the University of Kentucky Cooperative Extension Service. Producers should take advantage of these free services to maintain compliance with state law and realize the operation's production potential.

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Proper Care, Handling, and Facilities for Beef Cattle

Roy Burris, Kevin Laurent, and Steve Higgins

Proper care and handling of beef cattle requires knowledge of cattle and their behavior, a willingness to care for animals, along with adequate facilities for handling, feeding, and containing cattle. Beef cattle producers must take good care of their livestock and have too much at stake to do otherwise.

Animal Welfare

Cattle producers are concerned about animal welfare and have an economic incentive to provide proper care of animals that are under their care. Animal welfare refers to the humane care of animals and the belief that animals can contribute to human welfare by providing food, fiber, work, and companionship. Animal welfare also seeks to improve their treatment and well-being.

The National Cattlemen's Beef Association (NCBA) has adopted the following Producer Code of Cattle Care as guidelines for our beef cattle operations:

- Provide necessary food, water, and care to protect the health and well-being of animals.
- Provide disease prevention practices to protect herd health, including access to veterinary care.
- Provide facilities that allow safe, humane, and efficient movement and/or restraint of cattle.
- Use appropriate methods to humanly euthanize terminally sick or injured livestock and dispose of them properly.
- Provide personnel with training/experience to properly handle and care for cattle.
- Make timely observations of cattle to ensure basic needs are being met.
- Minimize stress when transporting cattle.
- Keep updated on advancements and changes in the industry to make decisions based upon sound production practices and consideration for animal well-being.
- Persons who willfully mistreat animals will not be tolerated.

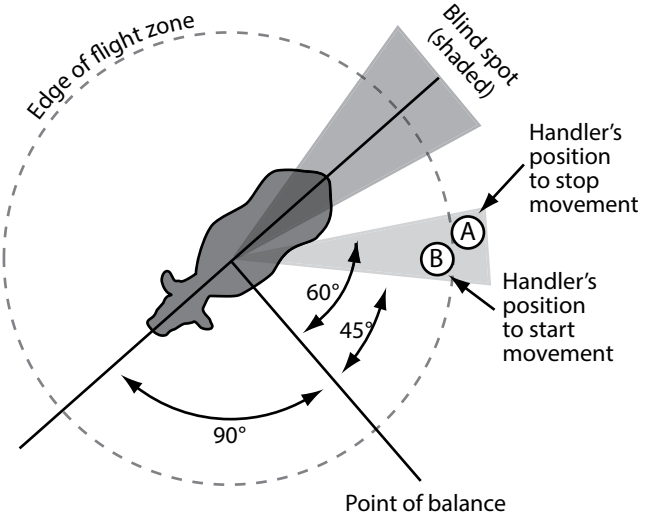


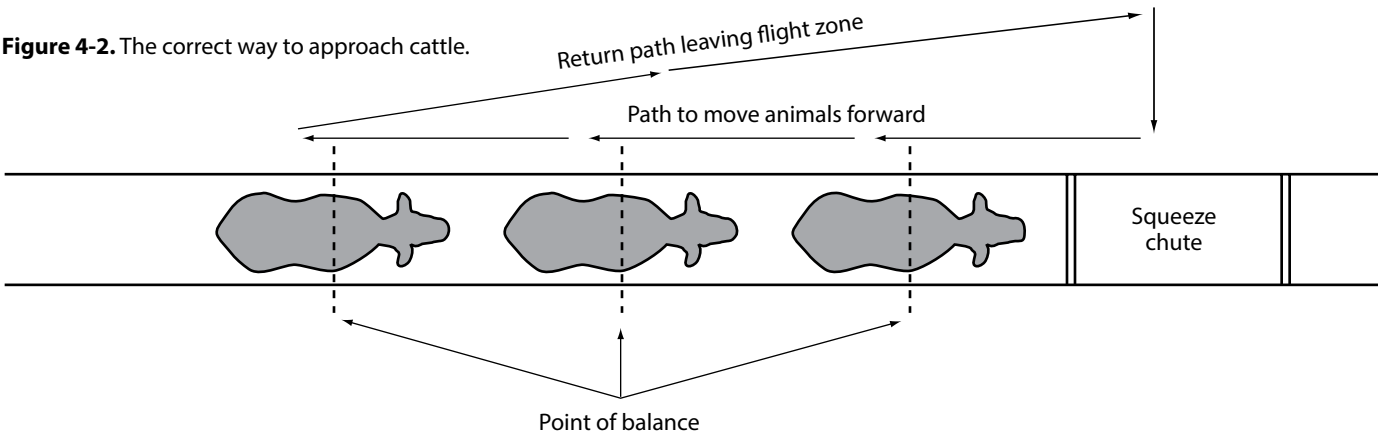
Figure 4-1. Flight zone of cattle.

Proper Handling of Cattle

Cattle producers should manage their herds so that they minimize stress and the chance of injury to themselves and their cattle. Cattle behavior is affected by both genetics and environment. Producers can improve the temperament of their cow herd by culling those animals intended for the breeding herd that are wild and retaining those that have calm dispositions. Many people need to change their actions in handling cattle. We tend to be impatient and aggressive, and we generally want to "chase" cattle instead of handling them in a calm, quiet, easy manner.

When moving cattle in pastures or bringing them into the corral, the position and movement of the handler is very important. Cattle have a flight zone (see Figure 4-1)—the area around them that they do not like for people to enter. The size of the flight zone depends on how

Figure 4-2. The correct way to approach cattle.



wild an animal is. This area can be very large in range cattle but might be only 5 or 10 feet in cattle accustomed to people.

The animal moves away when a person penetrates its flight zone. You can use this behavior to your advantage when moving cattle. Approach an animal slowly from a 45° angle, and it will move away from you in an orderly manner when you enter its flight zone. If you move too rapidly or try to get too close, the animal will turn back or break and run away. The best place to be is on the edge of the flight zone. This causes the animal to move away slowly. If you want the animal to turn, move up to its shoulders (point of balance).

Handling facilities should be laid out so that cattle are "funneled" into the corral as they are moved from the pastures. Cattle move better when they think that they are returning to their pasture, therefore the working area in the corral should be oriented so that they are turning back toward the pasture.

Work carefully when processing cattle. If you try to set a record for speed, you might end up unduly stressing or injuring your cattle. Cattle can be worked rapidly enough when they are handled skillfully and gently in a properly designed handling facility. Remember that animal health products, such as vaccines and implants, must be administered properly to be effective. Therefore, emphasize proper technique rather than speed.

Sorting cattle in a cow-calf operation is easier if you sort cows away from calves and work them after the calves. They readily will follow their calves. Use sorting paddles (instead of sticks) during this process.

Avoid any unnecessary noise. Clanging metal can also excite cattle. Rubber stops can be put under the tailgate of the squeeze chute. Parts that rattle should have gaskets put between them. There is no benefit to yelling at the cattle. Keep it quiet.

Approach cattle that balk in the chute during handling from the front (Figure 4-2) so that they will see you; then walk by them. They should move without any additional help. Cattle cannot see directly behind themselves, so approaching them from behind may cause them to balk.

Do not abuse cattle with electric prods or bruise them with sticks. Sorting paddles can be used effectively with little chance of abuse. Never use an electric prod in the genital or anal area, head, or udder of cattle.

Young animals that are intended for breeding replacements should have frequent exposure to people. Walk among them and hand-feed them after weaning, if possible. They should become docile and, at least, have a smaller flight zone.

Safety for the Cattle Handler

The proper handling of cattle should lead to more efficient cattle handling with less chance of injury to the handler or the cattle. Many injuries to the handler could be avoided by understanding animal behavior, being aware of environmental conditions, having proper facilities, and using safe handling techniques. In a survey on managing human risk in livestock handling, Kentucky researchers identified the following most critical safety action factors:

- Animal behavior
  - » Increase caution around bulls or cows with newborn calves.
  - » Understand and utilize the animal's flight zone.
- Environmental conditions
  - » Avoid handling cattle during extreme hot/humid or cold weather.
  - » Wear properly fitting clothing and protective footwear.
- Handling facilities and equipment
  - » Construct sturdy and durable handling facilities.
  - » Lay out facilities to take advantage of animals' natural behavior.
  - » Use proper and adequate restraining devices (chutes, ropes, head gates).
- Safe-handling techniques
  - » Be especially cautious around animals that are handled less frequently or are agitated.
  - » Do not trust or take animals for granted or become complacent with routine jobs.
  - » Match age, experience, and skill of the handler to the task at hand.

Humane Euthanasia of Cattle*

Cattle owners and handlers share a moral obligation to ensure the welfare of the animals that are in their care. When disease or injury diminishes quality of life or creates pain and suffering with little chance of recovery, euthanasia is indicated. Commonly referred to as "putting an animal down," euthanasia is a Greek term that means "good death." Its goal is to cause no pain or distress to an animal.

The topic of euthanasia is unpleasant. However, it is one task for which veterinarians and handlers should be prepared. Euthanasia is indicated in the following circumstances:

- Fractures of the legs, hip, or spine that are not repairable and result in immobility or inability to stand.
- Emergency medical conditions that result in excruciating pain that cannot be relieved by treatment (e.g., trauma associated with highway accidents).
- Emaciation and/or debilitation from disease or injury that may result in the animal being too weak to be transported.
- Paralysis from disease or traumatic injuries that result in immobility.
- Advanced eye disease (e.g., lymphoma or cancer eye in cattle).
- Disease conditions for which cost of treatment is prohibitive.
- Disease conditions for which no effective treatment is known (Johne's disease in ruminants), prognosis is poor, or time to expected recovery is unusually prolonged.
- Animals suspected of having bovine spongiform encephalitis (BSE) where there may be a threat to human health. (These animals should not be killed by gunshot or other methods that result in head trauma that might cause excessive damage or loss of brain tissue. Instead, suspect animals should be attended to by a veterinarian who can properly euthanize the animal and obtain brain tissue for diagnostic purposes.)

*Adapted from Shearer and Nicoletti. Procedures for the humane euthanasia of sick, injured, and/or debilitated livestock. University of Florida Extension http://www.vetmed.ufl.edu/lacs/HumaneEuthanasia.htm.

When conditions warrant euthanasia, the next consideration is method. Veterinarians can euthanize an animal with drugs that depress the central nervous system; this would probably be the preferred method. However, in many circumstances on the farm, gunshot is the only practical method of euthanasia. This procedure requires the selection of an appropriate firearm and bullet with sufficient velocity, energy, and size to pass through the skull and enter the brain. A.22-caliber hollow- or soft-point bullet is sufficient for young animals. However, larger adult animals require at least a.22-magnum solid-point bullet or preferably a 9-mm or.357-caliber bullet.

Proper placement is best achieved by holding the firearm within a few inches of the intended target. **Do not place the firearm against the head**. In cattle, the point of entry should be at the intersection of two imaginary lines, each drawn from the inside corner of the eye to the base of the opposite horn (or slightly above the opposite ear for polled cattle). As seen in Figure 4-3, this makes the point of entry in the center of the forehead above the center of the eyes—not between the eyes.

Euthanasia by the gunshot technique can result in involuntary movement and occasionally vocalization that may be misinterpreted as painful by an inexperienced person. Therefore, it is recommended that this procedure be performed out of the public view.

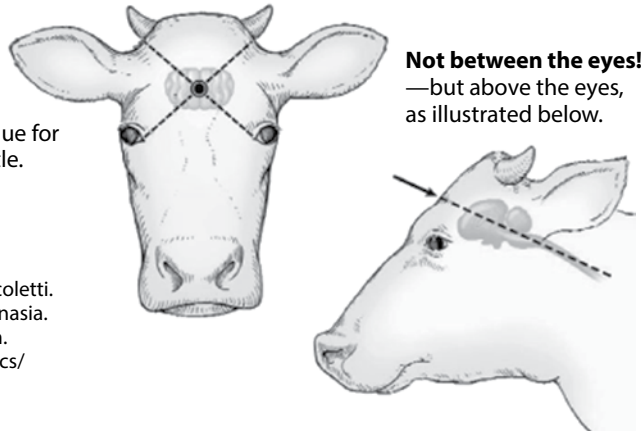


Figure 4-3. Proper technique for humane euthanasia of cattle.

Adapted from Shearer and Nicoletti. Procedures for humane euthanasia. University of Florida Extension. http://www.vetmed.ufl.edu/lacs/HumaneEuthanasia.htm.

Design and Construction of Handling Facilities

Cattle handling facilities are used to confine cattle safely and efficiently for close observation and to perform routine health and management procedures. Adequate facilities are an essential part of an efficient cattle operation for any producer who wants to improve marketing, cattle health, and production. A well-planned handling facility can help you save money by making easier practices such as preventive health management, pregnancy testing, implanting, controlling parasites, vaccinating, castrating, and dehorning.

The most obvious positive impact of improved cattle handling facilities would probably be on an operation's returns, including saved costs in labor. Most importantly, a good facility can prevent injuries to both workers and cattle. Safe handling also minimizes stress on cattle, which can reduce their weight and ability to fight disease and cause performance problems. Stress can also lead to bruising and injuries, which are quality defects.

The location of the facilities is critical. The most important points in selecting a site for handling facilities are: (1) easy access, (2) access to water and electricity, (3) good drainage, (4) security and biosecurity, (5) nearness to neighbors, and (6) future expansion.

Normally one-eighth to one-half acre of land is needed for siting working facilities. Trucks and stock trailers must have easy access to the facilities. An all-weather road is needed for accessibility under adverse weather conditions. A circular turning area is preferred to the backing of trucks and trailers, which may require a turning area of 130 to 150 feet in diameter. It is also desirable to locate facilities reasonably close to pastures for easy cattle movement.

It is important that cattle have access to water before and after they are worked through the facility. Electricity is needed when the facility is located inside a building, in case you need work or treat animals at night and want or need to track cattle performance and store data.

The site where you place the facilities must be well drained to avoid mud and sanitation problems caused by standing water. Avoid steep slopes (> 5%) to minimize problems of water pollution caused by manure runoff. The rough concrete floor in the squeeze chute area can be sloped (1% to 2%) toward an open drainage ditch or runoff storage pond outside the fences.

Locate your facility in as secure a place as possible in order to help prevent theft, vandalism, and accidental fire. Limit visitor access to control disease and to reduce interference with farm work. Cattle handling facilities are frequently located away from the farm manager's residence. If this poses a security problem, provide only one access road. Make access roads at remote sites visible from a public road or neighboring residence. You also need to think about good biosecurity management, reducing the chance of infectious diseases being introduced or spread on the farm.

Avoid sites that are directly next to neighbors' residences where odor, noise, dust, and flies might be objectionable when you are using the facilities intensively.

When planning a facility, always leave room for expansion, such as expanding the existing holding pen or adding pens.

Components

Components of a cattle handling facility include the holding pen, crowding pen, working chute, squeeze chute or head gate, loading chute, and scales. It is not necessary to use all of these parts in every system. Use only those that are needed and affordable. Table 4-1 gives the suggested dimensions for sizing facilities.

Holding Pen

Design holding pens to hold the maximum number of cattle to be worked at one time. For example, a producer with 30 cows needs a minimum of two pens to sort cows and calves. One pen would hold 30 cows and 30 calves and would be 1,020 square feet (20 square

feet per cow and 14 square feet per calf [see Table 4-1]). A second holding pen measuring 600 square feet would hold cows after they are sorted away from the calves. Other pens and access alleys could be added for more flexibility. Access alleys should be at least 10 feet wide and laid out to provide a desired traffic flow. Fences should be 5 to 6 feet high, depending on the breed, and built by setting 4- to 5-inch round wood posts 2.5 to 3 feet deep and 6 to 8 feet apart. Water, feeding area, and shade must be provided in at least one of the holding pens. This is especially important when sick animals are held in pens for a couple of days until they recover.

Table 4-1. Corral and working facilities' dimensions for beef cattle.

Facility Component	Recommended Dimensions		
	Up to 600 lb.	600 to 1,200 lb.	Over 1,200 lb.
Holding Pen			
Space per head (sq. ft.)	14	17	20
Pen fence			
Height (in.)	60	60	60
Post spacing (ft.)	8	8	8
Post depth in ground (in.)	30	30	30
Crowding Pen[1]			
Space per head (sq. ft.)	6	10	12
Post spacing (ft.)	4 - 6	4 - 6	4 - 6
Solid wall height (in.)	45	50	50 - 60
Working Chute[2]			
Straight side (in.)	18	22	28
Fully tapered—width at 32-in. height (in.)	18	22	28
Fully tapered—width at bottom (in.)	15	16	18
Minimum length (ft.)	20	20	20
Maximum curve angle (degrees)	15	15	15
Length for 16-foot outside radius (ft.)	45	45	45
Solid wall height (in.)	45	50	50 - 60
Overall height—top rail (in.)	55	60	60 - 72
Chute fence			
Post spacing (ft.)	6	6	6
Post depth in ground (in.)	36	36	36
Holding Chute/Squeeze			
Height (in.)	45	50	50
Width			
Straight sides (in.)	18	22	28
V-shaped sides, width at bottom (in.)	6 - 8	8 - 12	14 - 16
Length—with head gate (ft.)	5	5 - 8	5 - 8
Loading Chute			
Width (in.)	26	26	26 - 30
Minimum length (ft.)	12	12	12
Maximum rise (in./ft.)	3.5	3.5	3.5
Radius of a curved chute (ft.)	12 - 17	12 - 17	12 - 17
Spacing of 1 x 2-in. hardwood cleats (in.)	8	8	8

[1] Crowding pen: It must be of either circular shape (1/4 or 1/2 circle) or funnel shape.
[2] Working chute: It should be curved or offset (offset angle at 30° maximum).

Crowding Pen

The crowding pen is the confining area that "funnels" cattle into the single-file working chute. A circular crowding pen with solid sides is effective because the only visible escape route is through the working chute. If the crowding area cannot be made circular, it should be funnel-shaped; it should be constructed with one straight side and the other side entering the chute at an angle of about 30 degrees. A solid crowding gate should be used to keep cattle from seeing through it. It is recommended that the pivot post be constructed out of a 3- to 4-inch steel pipe or 8-inch wood post embedded in 4 feet of concrete. Gate height can be adjustable. The crowding gate needs a self-locking gate latch for both convenience and safety.

Working Chute

The purpose of the working chute is to align cattle into single file for treatment. It starts from the crowding pen and leads to the head gate. Cattle often balk or back up when they see the squeeze chute. The best working chutes are curved or have at least a 15° bend in them. The working chute should be at least 20 feet long, regardless of the herd size. Sloping the sides of the chute reduces the ability of an animal to turn around. Common faults are making the chute too wide, which permits calves to turn around, and inadequate construction, which causes the sides of the chute to spread when subjected to intense pressure. Use the recommended width suggested in Table 4-1. One-way gates in working chutes allow cattle to move forward in the chute but automatically prevent them from backing up. If cattle are not of uniform size, use adjustable chains so you can vary the gate height.

Head Gate or Squeeze Chute

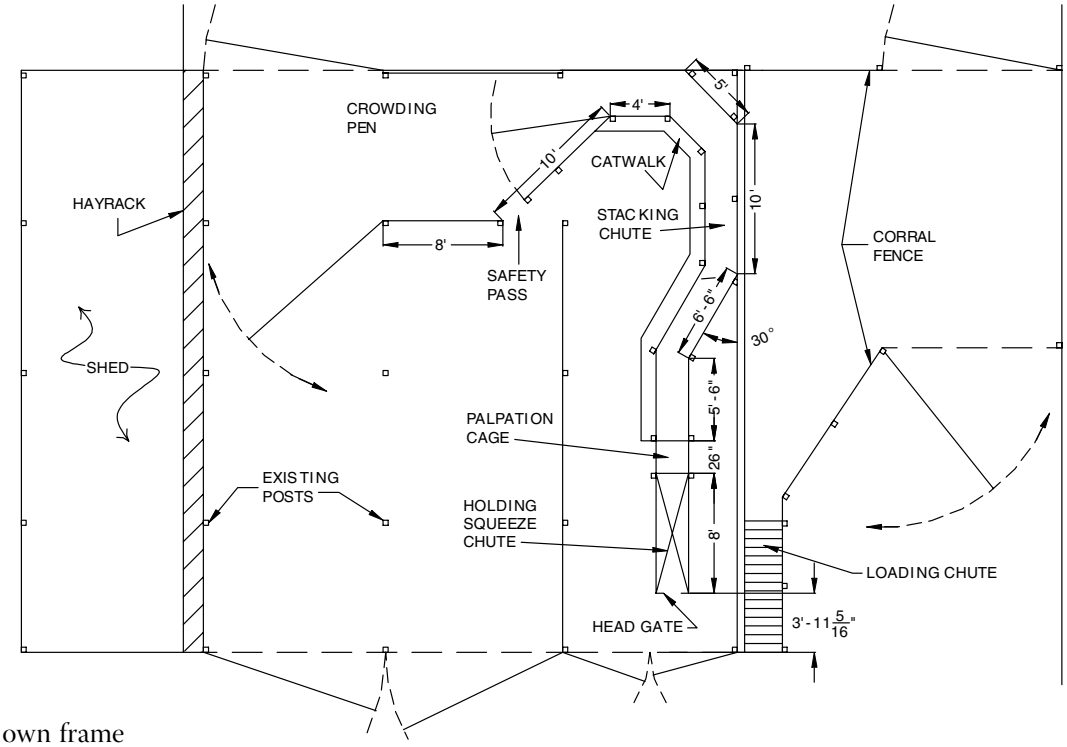
Located at the end of the working chute, the head gate and/or squeeze chute should hold the animal securely while it is being treated. The head gate should be sturdy, safe, easy to operate, and have a quiet action. It can be either manually or hydraulically operated. We recommended a self-catching and full-opening head gate for the small operations that are typical of Kentucky. Curved stanchions may offer more control of the animal's head, but they are more likely than the straight bar type to cause choking if animals go down. Many brands of commercial head gates are currently available. No matter what type of head gate you select, adjust it properly for the type of cattle being worked to prevent the animals or operator from being injured.

Loading Chute

Some producers consider a loading chute an essential part of their cattle handling systems. Those with fewer cattle may use "gooseneck" trailers for hauling and do not need a loading ramp. Cattle move better directly from the crowding pen to the loading chute, rather than moving through a long working chute.

Desirable characteristics for a loading chute include curved approach, solid sides, telescoping side panels, self-aligning dock platform or bumper, and circular crowding area. It also is desirable to locate scales near the loading chute. The slope of a permanently installed cattle ramp should not exceed 20 degrees. The slope of a portable or adjustable chute should not exceed 25 degrees. Other specifications are given in Table 4-1.

Figure 4-4. Corral layout in a tobacco barn.



Scales

Scales can be a valuable addition to handling facilities. They can help you obtain weaning weights and cow weights, evaluate gains, and test for performance. Single scales can have their own frame or cage for holding the animal or can be mounted in the form of load cells under a conventional squeeze. A single animal scale can also be positioned ahead of the squeeze and head gate. Electronic load cells are becoming popular among producers. Electronic scales are fast and easy to operate, but they require a power supply or batteries and have to be calibrated more often than either mechanical or hydraulic scales.

One handling facility layout will not fit all cow-calf operations. Determine the components you need, and design your layout to fit your particular type of operation, herd size, existing facilities, and materials available. Your objective is to have a facility that allows you to sort, restrain, process, and ship cattle as efficiently, safely, and economically as possible.

Adequate handling facilities need not be elaborate or expensive. Existing fence lines and buildings may be used in planning a facility. To save installation costs, many producers consider using materials other than wood or steel pipe. Materials such as used/recycled highway guard rails, cosmetic rejects from fiberglass or metal manufacturers (seconds), or grain bin sections may cost less than conventional materials but generally work best only in certain corral areas. In addition, surplus materials may not always be cost competitive with those made with wood or steel. Finally, alternative materials are often limited and available only at certain locations, while lumber or steel is generally both more plentiful and widely available. Always weigh the advantages and disadvantages of each material that may be used in a corral, including function, strength, and cost before making a final selection.

Figures 4-4, 4-5, and 4-6 show handling facilities of varying degrees of complexity, from simple facilities located in a barn corner or lot corner to a circular facility for 25 to 75 head.

Planning and Constructing Fences

Before you build new fences, replace existing fences, or consider more cross fencing, you must first plan. Your first consideration is having a well-built, permanent boundary fence. This is important so that:

- You have a fixed property line between you and your neighbor or between you and the highway.
- You can confine your cattle to your own farm. Liability for losses due to cattle/auto accidents or crop damage to surrounding farms can justify a well-built fence.
- Your neighbor's cattle are fenced off from your property, which can protect your crops and your breeding program.

When planning your pasture layout and fences, obtain copies of aerial photographs from your county Natural Resources Conservation Service office and sketch plans on them. Lay out the fences to follow contours of the topography, providing fields that are as large and as uniform as possible for major pasture divisions. Once you have laid out the fence lines, locate necessary lanes and gates.

Keep in mind the shape of pastures. Square pastures are the most efficient because they allow animals to obtain forage with minimum trampling damage and use the least amount of fence material for a given land area. They also can be subdivided with less trouble. A pie-shaped arrangement is sometimes used to give animals access to a central water source. In these cases, cattle tend to overgraze and trample the area closest to the water and graze less in the back of the pasture. A lane to water provides an alternative to the pie-shaped design and reduces the trampled area. Figures 4-7, 4-8, and 4-9 show how fences might be arranged on a farmstead (these diagrams are from Kentucky Cooperative Extension publica-

tion ID-74: *Planning Fencing Systems for Intensive Grazing Management*).

Gate placement is important for animal movement. Locate the gate in the corner of the paddock so that when the first cows move out, the others, especially calves, follow rather than going along the inside of the fence (see Figure 4-10). Never locate a gate in the middle of a fence line with no way to "funnel" the cattle toward it. All-weather surfaces placed in gateways help to alleviate mud.

Fence Types

Fence types vary from physical barrier fences, such as woven wire, barbed wire, high tensile, and board fences, to psychological barriers, such as electric high or low tensile wire or portable polywire or polytape type fences. All of these types are used in Kentucky, and each has its advantages. Factors for selecting fence type include:

- Affordability
- Maintenance
- Durability
- Effectiveness on the livestock to be contained

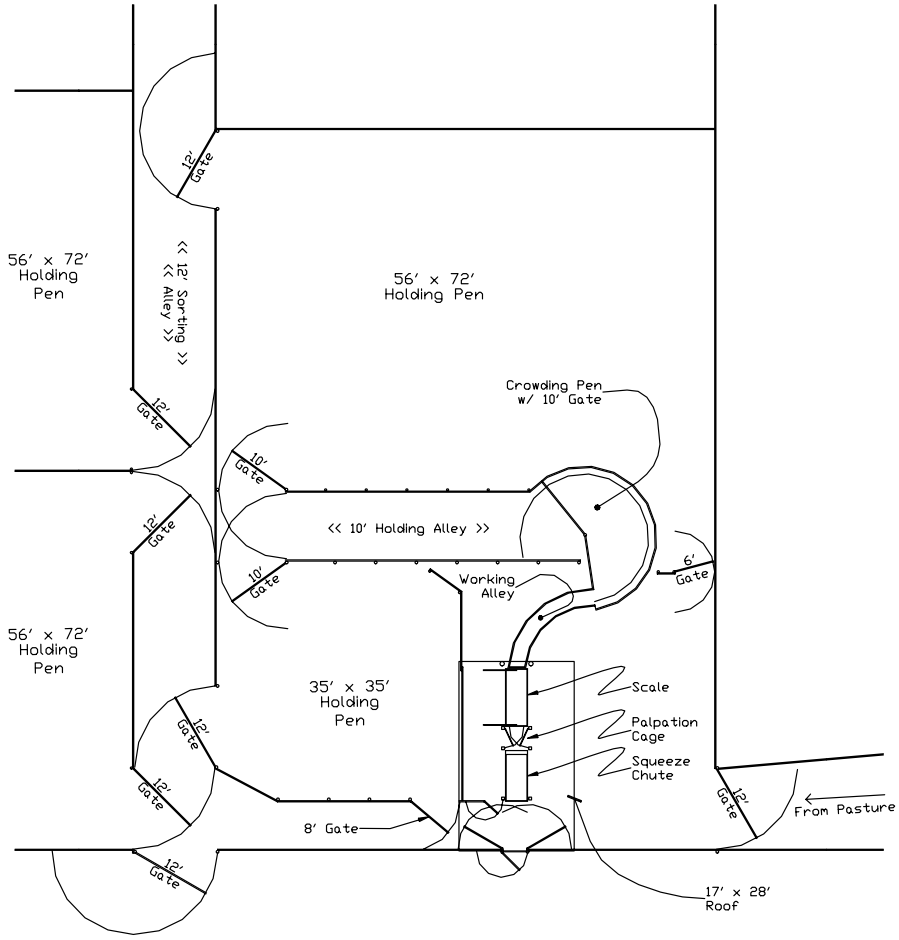
Woven Wire Fences

Woven wire fences are generally used for boundaries, lanes, and lots. A woven wire fence consists of a number of horizontal wires held apart by vertical wires called stays. The distance between horizontal line wires may vary from as close as 1½ inches at the bottom for small animals to as wide as 9 inches at the top for large animals. In general, the spacing between wires gets wider as the fence gets taller.

Woven wire fencing is available in many combinations of wire sizes and spacings and varies in numbers of horizontal line wires and fence heights. The height of most woven wire fencing materials ranges from 26 to 48 inches. Select fence height based on the animals' sizes and jumping abilities. Stay wires should be spaced 6 inches apart for small animals and 12 inches for large animals.

The standard design number is listed on the tag to describe the wire. For instance, a design number 10471211 indicates the wire has 10 horizontal wires and is 47 inches high, stays are spaced 12 inches apart, and stay and filler wires (wires between the top and bottom line wires) are 11-gauge wire. The top and bottom wires are generally two sizes larger. Standard woven wire fence heights are shown in Table 4-2; weights are shown in Table 4-3.

Figure 4-5. Corral layout at the University of Kentucky Research Center, Princeton, Kentucky.



Barbed Wire Fences

Barbed wire fences are made of two or more strands of smooth, galvanized-coated steel wire twisted together with two or four barbs spaced every 4 to 5 inches. Standard barbed wire fences usually have three to five strands of barbed wire stretched between posts spaced 15 to 25 feet apart. Barbed wire is sold in 80rod rolls (80 rods = 1,320 feet = ¼ mile).

Board Fences

Board fences are attractive, strong, and safe for animals. They are typically used as border fences around the farm or home or for crowding areas in cattle working facilities. Board fences consist of 1 to 2inch thick, 4 to 6inch wide boards nailed to wooden posts spaced 8 to 10 feet apart. For additional strength, stagger the joints on the posts. For example, using

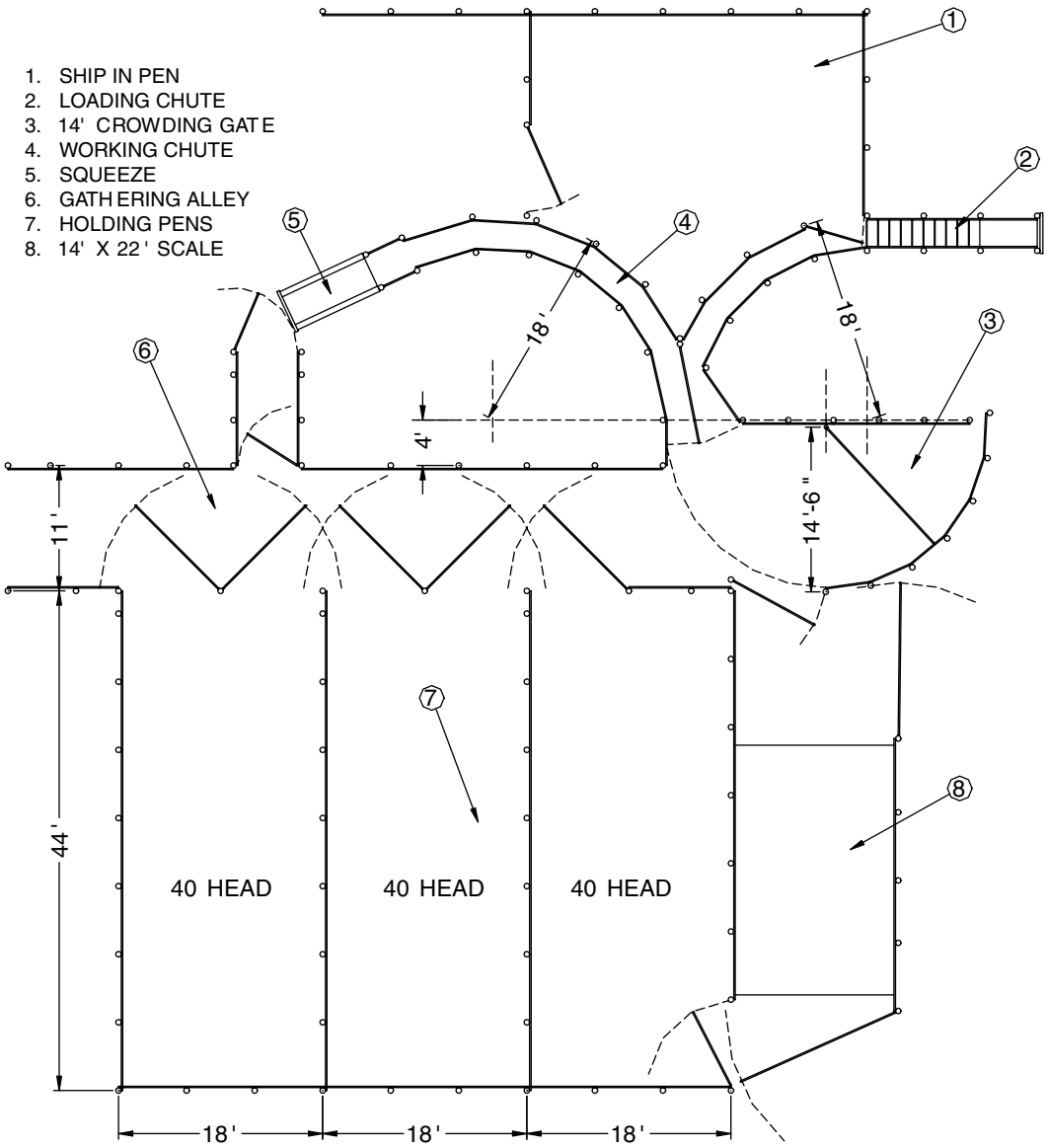
Table 4-2. Common woven wire fence heights.

Design No.	Horizontal Wires	Height (in.)
635	6	35
726	7	26
832	8	32
845	8	34
939	9	39
949	9	49
1047	10	47
1156	11	56

Table 4-3. Woven wire fence weights.

Weight	Gauge of Top and Bottom Wires	Gauge of Intermediate Line Wires
Light	11	14½
Medium	10	12½
Heavy	9	11
Extra heavy	9	9

Figure 4-6. Corral layout with receiving/loading.



four 16foot boards and posts spaced 8 feet apart, the top and third boards should continuously span a given post (with the post at the center of the boards), while the joints of the second and bottom boards should butt together on that same post. Do the reverse on the next post.

The price of lumber, nails, paint, and other materials, along with the labor required, makes the cost of these fences considerably higher than most permanent wire fences. Upkeep is also high, especially if untreated lumber is used.

High Tensile Fences

High tensile fences are an increasingly popular type of fence. First used in New Zealand and Australia, they offer several advantages over conventional fencing because they:

- are easier to construct
- last longer
- are less expensive to build than most conventional fences
- require less maintenance.

High tensile fences are constructed mostly with 12½- or 14-gauge Class III wires that have tensile strengths from 170,000 to 200,000 or more pounds per square inch (psi) and breaking strengths of approximately 1,800 pounds. This fence can withstand more than 1,100 pounds of livestock pressure without losing its elasticity, yet it is flexible enough to bend, wrap, tie in knots, or clamp with crimping sleeves. Wires are held in tension along wood, fiberglass, insulated metal posts, or a combination of posts and battens or droppers. Tension in the wire is maintained by permanent inline strainers. Adequate tension for 12½-gauge high tensile wire is 200 pounds, indicated by a tension indicator spring.

High tensile wire fences can be used with electricity to improve animalholding capability and predator control. It is important to use treated wood posts and set them properly in the ground with adequate braces to withstand the pressure caused by the tightly stretched wire.

Figure 4-7. Farm with two pastures. Further subdivision will permit better grazing management.

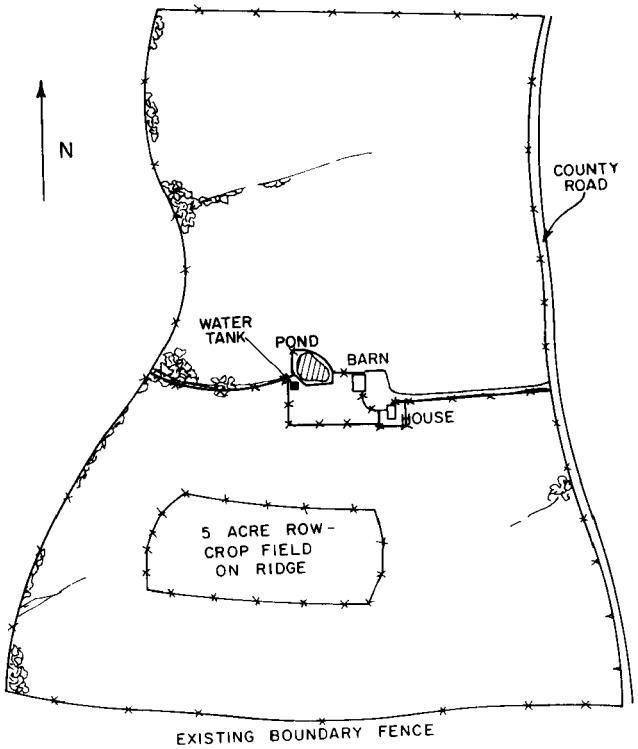


Figure 4-8. Subdivision to four paddocks using permanent (x-x-) and temporary (-) fence.

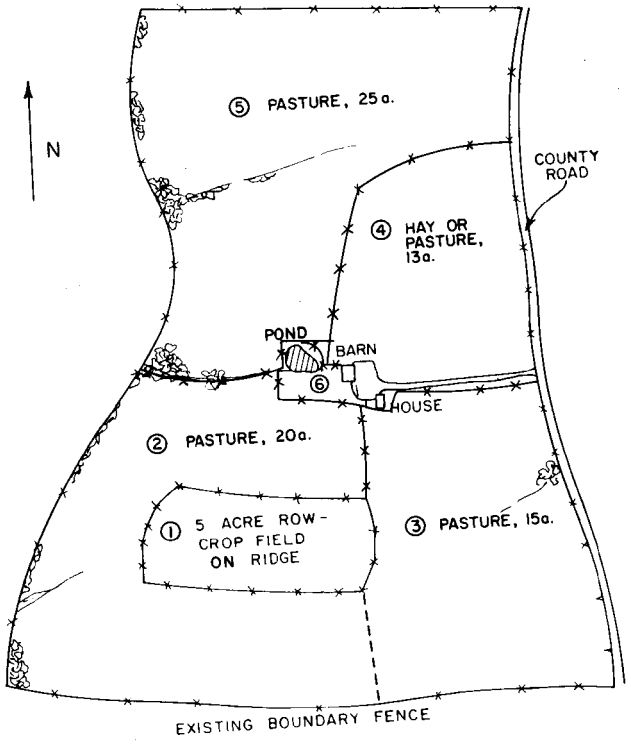


Figure 4-9. Subdivision to eight paddocks using portable fence.

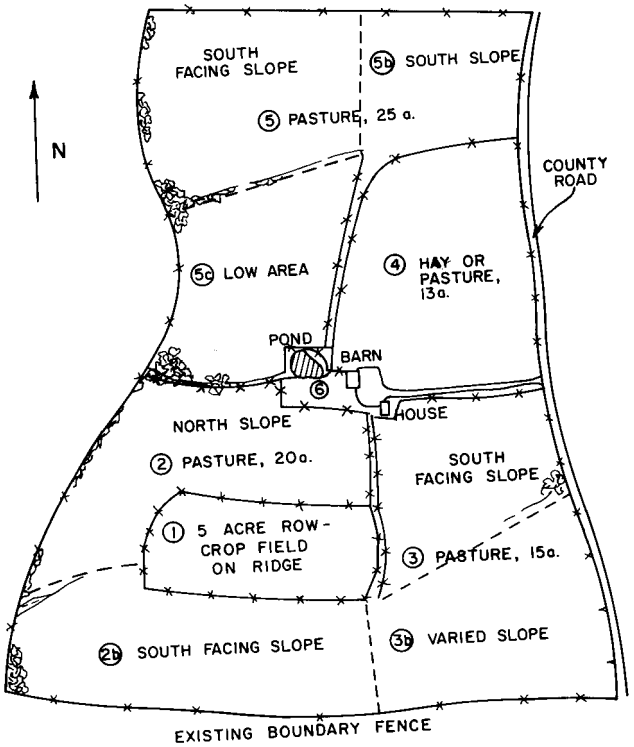
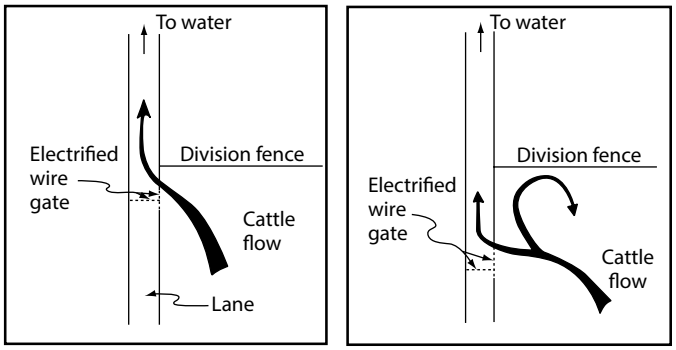


Figure 4-10. Gate placement is important to good animal movement.



Cable Fences

Cable fences are used primarily for confinement areas, such as holding pens, feedlots, and corrals. These fences usually consist of 3/8inch smooth steel wire cables stretched between anchor posts. The cables are normally made out of seven wires twisted together. Heavyduty springs are placed at one end of each cable to absorb the shock on the wires caused by animals pressing against them. Cables are usually passed through holes in wooden or steel posts with a turn-buckle to permit tightening.

Any number of cables can be used; however, a sixcable fence is often used for large animals. The spacing between cables depends on the type of animals to be confined.

Electric Fences

Electric fences are widely and successfully used in Kentucky. If constructed properly and energized with a controller designed to match the application, they can be an effective, safe, and inexpensive means of providing temporary and permanent fencing.

Electric fencing does not need to be strong because it seldom comes under pressure, but it must be well designed and constructed to absorb the impact of animals. Adequate power for the length of fencing and type of animals to be confined is also essential. Electric fencing has a low installation cost, is inexpensive to operate, can be used to extend the life of old permanent fences, can be used for deer and predator control, and can be built for temporary or permanent use. Electric fences are great for testing the location of permanent fences.

Various types of inexpensive, easily erected temporary electric fences are available. Probably the most popular are the polywire strands or ribbons—fine wires woven together with polyethylene fibers.

Polyethylene and steel braided wire (polywire) comes in various colors, although white is generally used. Black is the most difficult for animals and people to see. Brighter colors, such as orange or white, are also available. Polytape, particularly the extra-wide type, is easier to see than polywire and works better for horses and in other cases where visibility is especially important. Some newer polywires and tapes incorporate more wires so that the resistance to current is lower, allowing longer runs of wire. A practical maximum for the lower wire density polywires is about 1,200 feet.

It is important to keep weeds and grass cut away from the fence, especially when using low impedance controllers. Polywires with stainless steel wires are more durable, but electric conductivity is lower. Aluminum conducts electricity better but tends to break more easily.

Table 4-4. Comparison of common fences (1 post per 16 feet).

Types		Strands	Wire Gauge	Height (in.)	Stay Spacing (in.)	Cost Index[1]	Fence Life (yrs.)[2]	Upkeep
Permanent materials	Barbed wire, 2-point	3	12½		4	132	33	high
		4	12½		4	143	33	high
		5	12½		4	154	33	high
		3	14		4	121	18	high
	Barbed wire, 4-point	3	12½		5	132	33	high
		4	12½		5	143	33	high
		5	12½		5	154	33	high
	Woven wire, light weight	top, bottom	11	26	6	154	19	high
		filler	14½	32	6	165	19	high
	Woven wire, medium weight	top, bottom	10	26	6	176	30	medium
		filler	12½	32	6	187	30	medium
		filler	12½	39	6	198	30	medium
		filler	12½	47	6	220	30	medium
	Woven wire, heavy weight	top, bottom	9	26	6	209	40	low
		filler	11	32	6	231	40	low
		filler	11	39	6	253	40	low
		filler	11	47	6	275	40	low
	High tensile wire	3	12½			44	30	medium
		4	12½			55	30	medium
		5	12½			66	30	medium
		8	12½			110	30	medium
Temporary materials	High tensile wire	2	12½			20-35	30	medium
		1	12½			15-25	30	medium
	Polywire					10-15	710	medium
	Aluminum wire		9			30-40	30	medium
			13			25-35	30	medium

1 Labor costs are included, but the costs of electric controllers are not included.
2 Fence life based on combination of post and wire life expectancy in a humid climate.
Source: Adapted from Buschermohle et al., University of Tennessee Extension Pub. EP1095.

Aluminum, stainless steel, and high tensile wire also can be used. One advantage to using these type of wires is that they conduct electrical charges for longer distances than the small-diameter wires of polywire and polytapes. However, they are harder for the animals to see. To effectively train animals to stay within an electric fence, the animals need to see the wire as they feel the shock. Tying pieces of white cloth or brightlycolored plastic ribbon helps make these wires more visible.

An electric fence controller energizes the wire, and the moist earth completes the electrical circuit. Corners and end posts in temporary electric fences require minimal bracing. Line posts can be small and spaced far apart since the fence generally will be used for a short period of time.

Fencing Systems for Controlled Grazing

Table 4-4 provides a comparison of fence types to assist in making a selection that best fits your needs and budget. In Kentucky, the most economical fence type for controlled grazing fencing systems is often a combination of permanent electric smooth high tensile wire fence and temporary portable polywire (available on reels). An advantage of the reel is that it allows rapid setup and takedown of the fence for temporary arrangements or for strip grazing. Portable fiberglass fence posts are often used with the portable braided wire, using one strand of wire for large animals and two strands for calves. Since it is electrified, high tensile wire for the

permanent fence often can be installed using lowtension techniques. The following provides an overview of several types of fences and their appropriate place in a system.

For controlled grazing systems, the type of wire suggested for permanent boundary fence installations is New Zealand-type high tensile wire. This is 12½-gauge high tensile smooth wire that is heavily galvanized (Class III). Also, smaller diameter high tensile wires are now being used, particularly on interior division or paddock fences. These include 14½-gauge and 16-gauge thicknesses. The use of such wire has implications in energizer selection (since smaller wires have a greater resistance to current flow) and in allowable length of fencing to be energized.

For interior and temporary fences, a more flexible, low-tension wire is more popular. Small-diameter high tensile wire can be used, but many producers prefer a slightly softer grade of wire that is somewhat easier to work with when moving and handling the fence. An excellent alternative for temporary installations is braided wire containing very fine gauge steel wires braided with polyethylene strands into a wire, ribbon, or tape. These wires work well for installations of up to 1,200 feet. Because of the lower cross-sectional area of the steel, energizer requirements differ from those of smooth high tensile wire. Some newer braided wires have more steel (thus less resistance), so they can be used in longer runs.

Wire spacing depends on the type of livestock being fenced. Table 4-5 presents suggested wire spacings for permanent or temporary electric fences.

Fence posts are available in many different types in Kentucky (Table 4-6). Always try to find the best post to meet the demands of the situation. For example, it is best to use good, treated posts for permanent boundary fences, while light fiberglass or steel posts are more suitable for temporary fences in a controlled grazing cell.

Often the least expensive option is to cut your own posts or purchase untreated wooden posts. They are highly variable in size, shape, and durability (Table 4-7). Osage orange posts have a lifespan of 25 to 35 years; black locust or red cedar posts last 15 to 25 years. Other woods, such as oak, pine, and poplar, rot in just a few years unless they are pressure treated.

Wood posts come in a variety of sizes and lengths. The larger the top diameter, the stronger the post. Corners are the backbone of a fence. Whether you plan to install a woven wire, barbed wire, or high tensile wire fence, choose good corner posts. Corner and gate posts should have a diameter of at least 8 inches. Brace posts should be 5 inches or more in diameter. Line posts can be as small as 2½ inches, but larger diameter posts make the fence stronger and more durable.

Steel posts have several advantages. They weigh less, can be driven into the ground rather easily, will not rot, and are fireproof. They also help ground the fence against lightning when the soil is wet. They are more likely to be bent or forced out of line by livestock. A widely used method is to use wooden line posts every 50 to 75 feet to help keep steel posts from bending and improve the strength of the fence. Table 4-8 provides guidelines on post spacing for fences.

Fence construction includes setting posts, constructing braces, driving staples, and making splices. Corner and endpost assemblies are the foundation of the fence. The most common system is the horizontal brace or diagonal brace (Figure 4-11). Single-span assemblies may be used for fence lengths up to 10 rods (165 feet).

Table 4-5. Suggested wire spacings for permanent or temporary electric fences.

	Distance from Ground (for Wire Number)				
Cattle Type	**No. 1**	**No. 2**	**No. 3**	**No. 4**	**No. 5**
Cows	30″				
Cows and calves	17″	38″			
Hard-to-hold cattle	17″	27″	38″		
Boundary fence	5″	10″	17″	27″	38″

Table 4-6. Fence post characteristics.

Post Type	Bending Strength	Expected Life (yrs.)	Initial Cost	Fire Resistance	Maintenance
SteelT, concrete	fair	25-30	medium	good	low
Steel rod, 3/8″ dia.	poor	15-20	low	good	medium
Heavyduty fiberglassT	fair (flexible)	25-30	high	poor	low
Lightduty fiberglassT	poor (flexible)	15-20	low	poor	medium
Pressure-treated wood	good	30-35	medium	poor	very low
Untreated wood	good	7-15	low	poor	high

Table 4-7. Life expectancy of wood posts (years).

	Untreated	Treated (pressure)	Treated (soak)
Kind	**Years**		
Osage orange	25-35	—	—
Red cedar	15-25	20-25	20-25
Black locust	15-25	—	—
White oak	5-10	20-30	15-30
Hickory	2-6	15-20	10-15
Red oak	2-6	20-30	20-30
Yellow poplar	2-6	20-25	15-25
Sweet gum	3-6	20-30	20-30
S. pine	3-7	25-30	15-20

Table 4-8. Recommended post spacings.[1]

Fence	Spacing (feet)
Woven wire	14-16
Barbed wire	12-14
Electric[2]	20-75
High tensile[2]	16-60
Board	8
Corrals	6

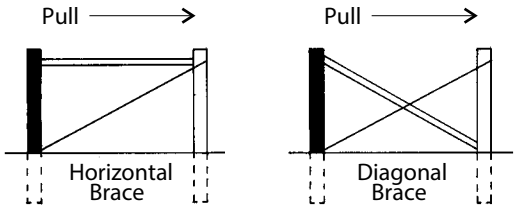
[1] Driven posts are 1.7 times as strong as tamped posts.
[2] Depending on terrain, use of battens.

Use double-span assemblies for 10 to 40 rods (165 to 660 feet). For more than 40 rods, use double-span construction plus braced line posts.

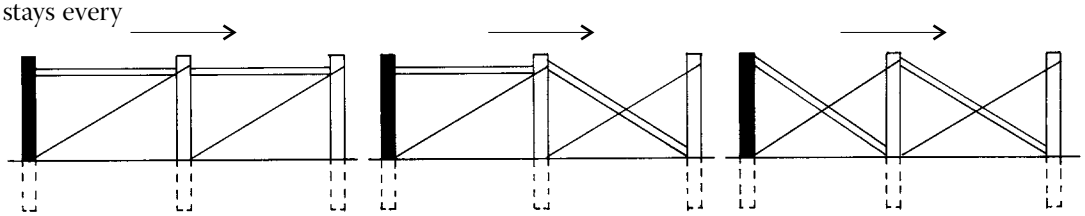
Suspension fences (shown in Figure 4-12) are long spans of barbed wire over level to rolling terrain. Moderately tensioned wire that moves freely between staples and posts is essential. Place line posts every 100 feet on level terrain and closer on rolling terrain. Put stays every 15 to 20 feet between posts.

Staple length, diameter, and type of post all affect the holding power. For treated posts, use 1¾ inch, 9-gauge galvanized staples with slash-cut points. Drive staples slightly off vertical so they straddle the wood grain and wires may move freely (Figure 4-13). String wire on the cattle side of the posts (unless appearance is important) and on the outside of curves.

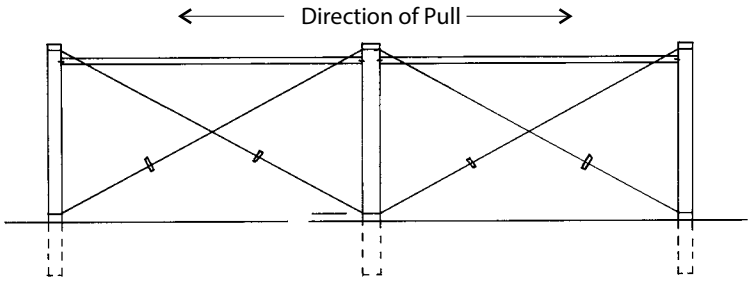
Figure 4-11. Corner and end-post assemblies for permanent wire fence.



Single-span brace assemblies of corner posts for short fences (up to 165 ft.)



Double-span brace assemblies of corner posts for longer fences (165 - 660 ft.)



Pull posts for the middle of long fences (over 660 ft.)

Feeding Facilities

Feeding facilities should be designed so that they are convenient to the animals and encourage feed intake. The size of feed bunk needed depends on the size of the cattle, whether they are all fed at one time, and whether they eat on both sides of the bunk. When selecting a feed bunk, consider drainage, manure buildup, and materials needed.

Enough space should be provided so that animals are not crowded, thereby reducing stress around the bunk or feeding area and improving intake. Table 4-9 gives feeder space requirements for various ages of cattle and feeding schemes. Proper opening spaces and throat heights

Table 4-9. Feeder space requirements for cattle feeding facilities.

Feeding Program	Space Requirement (inches/animal)				
	Calves (400-800 lb.)	Finishing (800-1,200 lb.)	Bred heifers (800 lb.)	Cows (1,000 lb.)	Bulls (1,500 lb.)
Once-a-day	18-22	22-26	22-26	24-30	26-30
Twice-a-day	9-11	11-13	11-13	12-15	12-15
Self-fed grain	3-4	4-6	4-6	5-6	5-6
Self-fed roughage	9-10	10-11	11-12	12-13	13-14

Source: Midwest Plan Service, Beef Housing and Equipment Handbook, MWPS6.

Figure 4-12. Suspension fence.

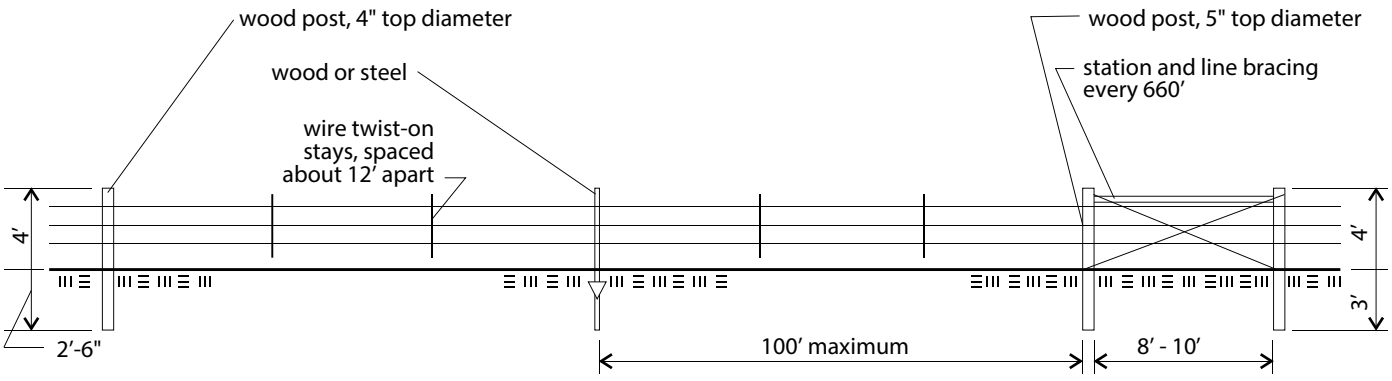
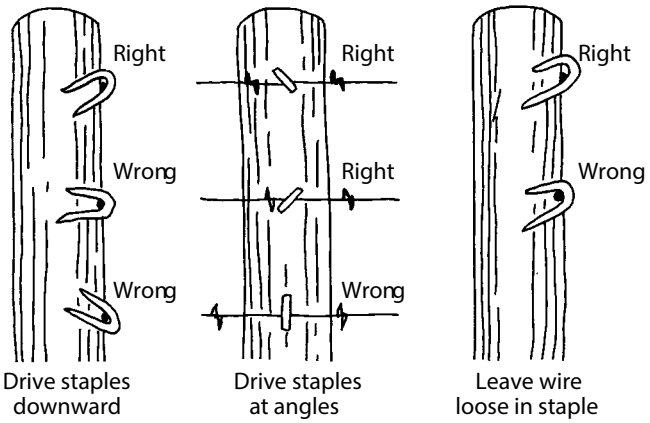


Figure 4-13. Proper stapling for fence construction.



for feed bunks are important to relieving stress and providing adequate access for cattle of varying sizes. Table 4-10 indicates suggested throat heights and neck rail heights for feed bunks for various sized cattle. This design is most appropriate for covered bunks and bunks inside buildings. The feed area allows for ease of cleaning, and the height of the bunk allows the cattle to eat in a more natural grazing position. In facilities where cattle have access to both sides of a bunk, use a partition on both sides of the feed. Other design options, including elevated bunks or mangers, are available in MWP S6: *Beef Housing and Equipment Handbook*, and through the University of Kentucky Plan Service.

Many Kentucky cattle producers successfully feed cattle in bunks without any roof or covering. For summertime feeding, however, feeding under roof is strongly encouraged for high-producing animals. This reduces heat stress and encourages animals to use the bunk. For winter conditions, some type of windbreak is advised if the bunk is on a ridge top or open to northwest winds. Ideally, a feed bunk offering cattle access on both sides should be oriented north-south, so the surfaces on both sides of the bunk have an opportunity to dry out from exposure to the sun. For bunks located outside or in locations where manure is not scraped frequently, a step (4 to 6 inches high and 12 to 16 inches wide) may be desired to improve access and minimize the problem of cows defecating in the bunk. For bunks with feed-retaining walls on both sides, increase the depth and/or width for bulky feeds, such as silage. Table 4-11 provides guidelines for bunk widths and apron construction.

Pad Construction

Muddy conditions at livestock operations can have detrimental effects on cattle performance. Animals spend considerable amounts of energy to move through mud, resulting in higher feed costs and reduced weight gain by livestock. Storage of hay on wet ground results in increased moisture levels on the bottom of the bale and substantial losses of both yield and forage quality. Producers frequently use crushed rock in feeding areas in an unsuccessful attempt to minimize mud.

One way to avoid muddy conditions is to build an all-weather surface for cattle and vehicle traffic. All-weather surfaces are generally built with concrete or asphalt and often with geotextile and gravel. Concrete feeding pads (figures 4-14 and 4-15), are expensive but are excellent feeding structures.

Geotextile and gravel pads constitute a much cheaper option as compared to concrete, but they require more maintenance and can potentially contribute to groundwater contamination if manure accumulates on the surface of pads. Nonetheless, such pads have been used with success in many dairy and beef facilities in several states. Producers have enthusiastically adopted these pads for heavy use areas, and cost share programs have enhanced the rapidness of adoption.

The original development of geotextiles focused largely on nonagricultural uses: subgrade, roadbed, parking lot construction and stabilization, soil reinforcement,

Table 4-10. Throat and neck rail heights for feed bunks.

Age (mo.)	Weight (lb.)	Throat	Neck Rail
		Height (in.)	
6-8	360-490	14	28
9-12	490-650	15.5	30
13-15	650-780	17	34
16-24	780-1,200	19	41
Cows	1,200-1,500	21	48

Source: Bickert, 1990, NRAES38.

Table 4-11. Suggested bunk widths and apron construction characteristics.

Bunk Width		Dimensions
a.	Both sides feeding	
	Calves	36″
	Heifers	48-60″
	Cows	48-60″
b.	One side feeding	18″ bottom width
	Bunk apron	
	Width	10-12′
	Slope	¾″-1″/ft.

Source: Midwest Plan Service, Beef Housing and Equipment Handbook, MWPS6.

Table 4-12. Minimum requirements for woven and nonwoven geotextiles.

Parameter	Woven Geotextile	Nonwoven Geotextile
Grab tensile strength (psi)	200	150
Bursting strength (psi)	400	320
Elongation (%)	< 50	> 50
Puncture strength (psi)	90	80
UV light (% residual tensile strength)	70	70
Apparent opening size	#100	#40
Permittivity (1/sec.)	0.1	0.7

erosion and sedimentation control, etc. Geotextile fabric applications in agriculture are designed to keep soil and gravel (or other earthen materials) separate. The fabric improves stability, load-bearing capacity, and drainage of the site. There are basically two type of geotextile fabric: woven and nonwoven, both made from either woven or spun polypropylene material. The main distinction between different styles of geotextile fabric is the type of yarn used. The Kentucky Natural Resources and Conservation Service practice standard specifies the minimum requirements for both woven and nonwoven geotextile (Table 4-12). The practice standard also specifies that a two-layer gravel base consisting of a coarse aggregate (No. 4; 6-inch layer) and a fine cover layer (dense grade aggregate, 2-inch layer) are placed on top of the geotextile fabric. The finer cover improves cow comfort and welfare, reduces the potential for foot injuries, and reduces damage from scraping the surface.

A 4- to 6-inch layer of No. 4 rock is suggested for the base material, which is placed above the filter fabric. A 2 to 3inch cover of sifted lime or dense grade material allows for easier scraping of the surface and less loss of rock through the box spreader. Maintenance of geotextile and gravel pads includes periodical manure scraping and replenishment of the finer surface cover that can be removed to some extent during scraping operations.

Figure 4-14. The vertical slats, of the winter feeding structure, provide containment of the conserved forage, which reduces waste by cattle. The raised feed table provides feed within reach of cattle, while limiting exposure to animal manure. A broomed concrete finish provides traction for cattle and vehicular traffic. The concrete surface also eases mechanical cleaning. (Metal feed panels can also be used as a substitute for wood).

Figure 4-15. A winter feeding structure, known as a Bo Renfro structure, that serves two pastures. The structure is within 150 feet of hay storage and can loaded with hay from the farmstead without entering a pasture.

Pens for Weaning Calves

Improving management at weaning is vital for the success of a cow-calf operation. Besides calving, the most stressful period in the life of a calf is at weaning. This time period is vital to the cow-calf producer also. Weaning is the end of the production process for most operators and represents the majority of annual income. Minimizing the stress the calf faces helps ensure that the year's work was not wasted and the calf continues through the production process. Weaning is one of the primary factors affecting calf marketability.

Corral line fence for newly weaned calves needs to ensure good restraint and safety. A wide variety of materials are used in building corrals. Most typical would be post and rail or plank fence (2'x6' planks). Fence visibility is important in weaning pens. Smooth wire and cable fences are not recommended unless at least one plank is attached to the fence at the calves' eye level.

Small pens are preferred over larger lots because large lots encourage fence walking and make it more difficult for calves to find feed and water. We recommend building pens narrow and not too deep to prevent calves from bunching up far away from the feed bunk. Provide at least 100 to 150 square feet per head in lots that provide good footing. Limit pens to 60 head per pen. The feed bunk and water source need to be easily accessible and recognizable.

Depending on calf size, 18 to 26 inches of bunk space per calf should be provided when starting calves and for calves limit-fed or fed just once a day. Started calves being fed twice a day to appetite should have 8 to 11 inches of bunk per calf. Generally, 10 inches of bunk per calf is required for self-fed roughage. Feed bunks should be located to encourage calves to eat and provide convenience in feed delivery. Considerations include drainage and wind protection. Calves prefer to eat downwind. Drainage should be away from bunks. Preference (depending on site) is generally for bunks or for the bunk line to be oriented north to south for sun exposure and minimizing frozen

manure pack buildup in the winter. Temporarily placing portable bunks against and perpendicular to the fence line is an excellent technique to achieve the goal of bunk-breaking calves. Fence-line feeding may use pre-cast concrete bunks, wood plank bunks, or through-the-fence feeding on the ground or a concrete slab. Generally, bunk height for calves should be less than 30 inches from the ground. Bunk design should minimize areas for accumulation of waste and spilled feed, which contributes to odor, fly, and rodent problems.

Having water available at all times is one of the most important considerations in setting up weaning pens. Weaning calves will consume less than 5 gallons per head per day during cold weather and up to 15 gallons per head per day in hot and humid summer conditions. It is recommended that 1 foot of tank be provided for every 20 head or one waterer or drinking bowl space provided for every 25 to 30 head in the lot. Water depths of 6 to 8 inches are preferred. Use deeper tanks where supply capacity is limited. Waterers or tanks placed in the fence line allow new arrivals to quickly find the water as they travel the fence line acquainting themselves with the pen. However, waterers located in the pen provide more opportunity for timid animals to drink. Let waterers run over for the first two days after calves are moved into pens. Consider float-operated waterers for a fresh supply of water. Of the many waterer choices commercially available, considerations in addition to cost include durability, ease of cleaning, energy cost, and protection from freezing. Frost-free and heavily insulated nonheated waterers are commercially available.

Provide shelter and/or shade as a good management practice. We recommend 20 to 40 square feet of shelter/shade per head.

Lot for Mature Bulls

In order to have a controlled calving season that provides for a uniform calf crop and ease of management, bulls must be confined away from the cow herd. Bull performance and working life are also affected by management. Good bull management ensures (1) bull fertility at the start of the breeding season, (2) good health, (3) sound feet, (4) proper feeding, and (5) minimal risk of injuries to handlers, bulls, and animals to be bred.

Keeping a bull in a small area for too long can lead to lameness and breeding difficulties. Have a bull pasture that is somewhat isolated, and make sure the bulls are protected from extreme weather. When bulls are kept in a lot, you should provide ample room for exercise (1,200 to 1,500 square feet per bull). Provide 30 to 36 inches of feeder space for each bull. Two-strand electric fences can control bulls trained to recognize an electric fence before being turned out. Provide a more durable fence (with 2½-inch pipe rails or 2'x6' planks) in areas near the farmstead and places where the possibility of bulls getting out can cause a dangerous situation.

Water bowls must be anchored firmly to prevent damage to or by the bull. Provide at least 27 gallons of water per bull per day during hot and humid weather. Water depths of 6 to 8 inches are preferred. Use deeper tanks where supply capacity is limited. As with weaning pens, consider float-operated waterers for a fresh supply of water.

Seasonal Watering Systems for Controlled Grazing

The economic benefits of controlling how and where your cattle graze are well documented. Increased forage utilization, greater stocking rates, greater legume persistence, reduced hay feeding, and more uniform nutrient recycling are just some of the many benefits producers can take advantage of when practicing some form of controlled grazing. However, one of the greatest challenges to implementing a controlled grazing system is the delivery of stock water to the grazing animal.

Water is probably the most important, yet often overlooked, nutrient that cattle require. Ruminant nutritionists have known for quite some time that water intake drives dry matter intake. In other words, when water intake is limited, dry matter intake decreases and, as a result, performance or gain declines. Research has also shown that when water was available in the paddock near the grazing animal, average daily gains were higher.

The location of water not only affects performance but also the social and grazing behavior of the herd. Studies at the University of Missouri have shown that when cattle must travel more than 800 feet to water, they tend to move as a herd and spend more time loafing at the water point. Conversely, when water was less than 800 feet away, cattle tended to go to water in smaller groups and spent less time at the water point. They also found that grazing and nutrient distribution was more variable when cattle were forced to travel farther to water. Forage utilization ranged from 50% closer to the water point (200 feet) to less than 20% farther from the water point (1,100 feet).

Using Lanes for Water Access

The use of lanes leading to a central permanent water point has in some cases been a viable solution to water access for controlled grazing systems. Lanes have a distinct advantage when it comes to moving or sorting cattle for treatment or artificial breeding. But the continued use of lanes can lead to erosion and affect nutrient recycling. Missouri research has also shown that when lanes were used for water access, 13% of manure was deposited in the lane and not on the pasture. Since cattle excrete approximately 80% of the N, P, and K they consume, any practical means of encouraging this return of nutrients to the growing pasture should be explored.

The Seasonal Water System Concept—Move the Cattle and Move the Water

Building permanent water points in every paddock is a costly proposition and restricts paddock design changes. A low-cost option for delivering water to grazing cattle is the use of small lightweight portable tubs with full flow valves, which have evolved over the last 15 years. These tubs combined with quick coupler fittings, borrowed from the irrigation industry, have revolutionized water delivery in controlled grazing systems. The quick couplers work much like a hydraulic coupler on a tractor. Water from the pipeline only flows into the tub when the hose leading to the tub is plugged into the coupler. So by strategically locating quick couplers along the pipeline, water can be accessed anywhere it is needed. Logically, couplers should be located where they can serve multiple paddocks; however, at $16 apiece, the added flexibility

of including extra couplers in the system is money well spent. The concept is very simple. When you move the cattle to the next paddock or pasture, you simply uncouple the tub, dump the water, and move the tub to the quick coupler in the next paddock. You move the cattle, and you move the water with them.

There are basically two options of pipe to use in a seasonal water system: conventional PVC, which must be buried, and high-density, UV-stabilized polyethylene pipe, which can be used in aboveground applications. The cheapest and simplest short-term option is an aboveground application using the high-density pipe. For most small operations in Kentucky, one day of rolling out pipe and attaching couplers is all that is needed to have water in every paddock. However, this type of system does have some obvious drawbacks. The pipe is exposed to weather, field work, and mowers and, although the pipe is very flexible and can be driven over, it must be protected anywhere it will be crossed repeatedly, such as gateways. Also, some systems must be drained at the end of each grazing season to prevent bursts from winter freezing.

One great advantage of an aboveground system is flexibility. Any changes in paddock design can easily be accommodated by simply dragging the waterline to a new location. Also, location of couplers can be changed to reduce water areas around the water point.

Over the long haul, a belowground system is probably the best option, especially on land you own. Water from belowground systems will be cooler, and PVC pipe, which is slightly cheaper than the high-density pipe, can be used. The longer life of a belowground waterline should more than offset the extra cost of burying the line. Access to quick couplers in a belowground installation can be accomplished by using 6-inch PVC pipe or plastic water meter housing. If using PVC as an access tube, a 6-inch PVC cap (which may be costly) or an old disk blade will serve as a cover when not in use.

The cost of a seasonal system will vary according to materials, size, and type of system. A conservative estimate for an above-ground system is about $20 per acre for a 50- to 75-acre farm. If you figure the system will last at least 10 years, the cost is about $2 per acre per year. Belowground systems carry a higher initial cost but should last at the very least three times as long. Cost-share programs may be available in many areas to improve your facilities and take your grazing program to the next level.

Keys to Making It Work

There are several rules to follow to ensure success with small portable tanks:

Keep water within 800 feet of the grazing animal. This will discourage herd movement and loafing time at the water point.

Protect the tank and coupler. Never allow cattle to have full access to the tub. This can be accomplished by locating the tub slightly under a polywire fence.

Maintain a minimum flow rate of 6 gallons per minute. A properly placed 60-gallon tub allows three cows to drink at one time. Since cattle can drink approximately 2 gallons per minute, a 6-gallon flow rate will allow the tank to recharge as the cattle drink. Pipe size, pressure, and elevation all affect flow rate. Seek help from your county Extension agent or local Natural Resources Conservation Service office before purchasing pipe.

Do not provide shade at the water point. Shade + water = mud and waste. Anything that encourages cattle to loaf in one area means fewer nutrients are being recycled on the growing pasture.

Stock Water for Winter Grazing

One of the great resources we have in Kentucky is our fescue forage base, which, when Mother Nature cooperates, can provide a tremendous amount of low-cost winter grazing. Obviously, seasonal systems with exposed tubs are not an option for winter stock water. However, the beauty of the seasonal system is that it is not needed during the winter anyway. Cattle water intake during the winter is approximately half of summer intake. Additionally, cattle are not as attracted to the water source as they are during the summer and are willing to graze farther from water. The 800-feet rule can be broken at this time of the year. So strip grazing stockpiled fescue, beginning at the permanent winter water source, becomes a simple and effective strategy. Take notice of where cattle spend their time during winter grazing. It is usually out on pasture next to the strip graze fence. Therefore, this is where most of the dung pads will be found, providing yet another advantage to strip grazing.

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Managing Reproduction

Les Anderson and Ben Crites

Reproductive efficiency is the single most important factor affecting gross returns in a cow-calf operation. Even though reproductive efficiency determines gross income, few producers actually have a plan to regulate or control reproduction in their cow herd. Ideally, one should strive to wean a calf from every cow exposed to breeding and have every cow calve within 20 to 30 days from the start of the calving season. More realistically, an excellent overall goal would be to wean a calf from greater than 90 percent of cows exposed to breeding and have 80 percent of the calves born in the first month of the calving season. This goal can be achieved through application of sound reproductive management practices. These practices include:

- Proper nutrition of the brood cow
- Estrous synchronization for either natural service or artificial insemination (AI)
- Proper development of heifers and young cows
- Disease prevention
- Minimizing calf death loss
- Using fertile bulls
- Culling infertile/inefficient cows

The term "reproductive efficiency" is confusing to many cattle producers. The industry is full of terms and calculations used to determine reproductive efficiency. Some of these are listed below.

Conception Rate: Percentage females that conceive at one estrus. This calculation is best understood using an example. If a producer synchronizes 20 cows for AI and 15 of them conceive to the AI then the conception rate to AI was 75 percent.

Pregnancy Rate: Percentage of cows pregnant at the end of a breeding season. Calculated by dividing the number of cows pregnant at the end of the season by the total number of cows exposed to the bull.

Calving Rate: Percentage of cows that calve. Calculated by dividing number of cows that calve by the number of cows that were exposed to the bull.

Equation 5-1.

$$\frac{\text{Number of calves weaned}}{\text{Number of cows exposed for breeding}} = \text{Percent calf crop}$$

Equation 5-2.

$$\frac{\text{Total pounds of calf weaned}}{\text{Number of cows exposed for breeding per cow exposed}} = \text{Pounds of calf weaned}$$

Equation 5-3.

$$\frac{\text{Annual cow costs}}{\text{(average weaning weight) x (\% calf crop)}} = \text{Breakeven price}$$

Weaning Rate: Percentage of cows that wean a calf.

Reproductive efficiency is best evaluated by three calculations; percent calf crop weaned, and pounds of calf weaned per cow exposed, and break even.

Percent calf crop is directly influenced by the number of cows that become pregnant and the number of pregnant cows that wean calves (Equation 5-1).

The calculation of pounds of calf weaned per cow exposed combines weaning performance and pregnancy rate. Weaning performance is most directly influenced by the age of the calf. Thus, pounds of calf weaned per cow exposed indicates not only the fertility of a herd but also the calving performance (Equation 5-2).

A breakeven in a cow-calf operation is derived by the formula in Equation 5-3.

The denominator that drives this equation is directly influenced by reproductive success or failure in any given herd. Average weaning weight is affected by calving distribution (i.e., early born calves weigh more at weaning than late-born calves). Economic analyses of herds in other parts of the United States show that high-profit cattle producers average 70 percent of their calves born during the first 21 days of the calving period. Calves grouped this close to one another in terms of birth date logically are more uniform at weaning than calves born during the second or even third 21-day period in the same calving year. Larger groups of uniform calves are more valuable and are easier to manage in terms of health and feeding programs.

Reproductive Anatomy of the Cow Tract

The cow's reproductive tract is located in the pelvic and abdominal cavities and consists of a pair of ovaries, oviducts (also called fallopian tubes), a uterus, a cervix, a vagina, and a vulva (see Figure 5-1).

Ovaries

Ovaries produce the female sex cells (eggs, or ova) plus estrogen and progesterone. Each egg is produced in a blister-like structure on the ovary called a follicle. There are cells in the follicles that produce estrogen. High levels of estrogen make the cow "come into heat" (estrus) and stand to be ridden by other cows or bulls. After the egg is released from the follicle, the follicle changes to a corpus luteum, or "yellow body." The corpus luteum produces progesterone ("pregnancy" hormone), which is vital if conception occurs and pregnancy is to be maintained.

Figure 5-1. A cow's reproductive system.

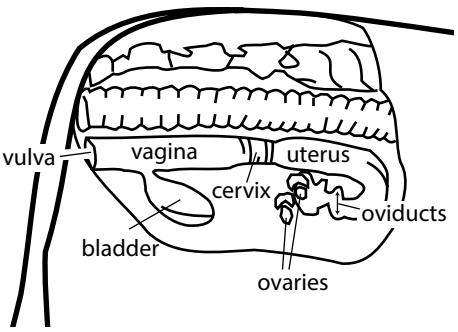


Table 5-1. The heat cycle of the cow.

	Average	Range
Duration of heat (hour)	14-18	12-30
Ovulation (hours after beginning of heat)	30	18-48
Length of heat cycle (days)	21	17-24

Table 5-2. Origin and action of female reproductive hormones.

Structure	Hormone	Action
Ovarian follicle	Estrogen	Stimulates heat and release of egg
Ovarian corpus luteum	Progesterone	Maintains pregnancy, inhibits estrus
Uterus	Prostaglandin	Regresses corpus luteum

Oviducts

Oviducts are a pair of tubes that extend from the ovaries to the uterine horns. Immediately after ovulation, the egg is caught by the funnel-like portion of the oviduct and transported through the oviduct to meet the sperm of the male. Fertilization occurs in the oviduct and the newly fertilized embryos resides in the oviduct for about five days.

Uterus

In a cow, the uterus has a body and two horns. The body of the uterus is located near the cervix. Semen is deposited here during artificial insemination. The sperm cells from the male move from the body of the uterus to the oviducts by way of the uterine horns. The uterine horns house the developing fetus during pregnancy.

Cervix

The cervix connects the vagina to the uterus. It forms a gateway between the uterus and the vagina. The canal through the cervix is tortuous and is tightly closed or sealed during pregnancy. During estrus, estrogen stimulates cervix secretions (mucous) and relaxes the cervix. Thus, the canal opens and the cervical mucous moistens the canal.

Vagina

The vagina is the birth canal during calving and the site where semen is deposited if the cow is serviced by a bull. There is a "blind pouch" in the vagina that has little significance except but it frequently presents a problem for inexperienced artificial insemination technicians because the tip of the insemination rod may be placed in it during insemination.

Vulva

This is the external opening or entrance to the cow's reproductive tract. It becomes swollen and moist during estrus. The vulva also becomes very swollen and relaxed as calving (parturition) approaches.

The Estrous Cycle

Estrus (heat), ovulation, and pregnancy are controlled by hormones. Estrus and ovulation occur as a cycle. Estrus, the time when the cow will accept a bull, generally lasts about 14 to 18 hours. Ovulation generally occurs about 30 hours after the beginning of heat. If pregnancy does not occur, the cycle repeats itself in about 21 days (see Table 5-1).

The fertilized embryo begins a series of cell divisions as it migrates down the oviducts. It attaches to the wall of one of the uterine horns where it is nourished during pregnancy. The gestation period (pregnancy) lasts about 283 days. Gestation length varies both within and between breeds. Typically, European breeds (i.e., Simmental, Charolais, etc.) have longer gestation periods than British breeds (i.e., Angus, Hereford, Shorthorn). Management at calving time is discussed later in this chapter.

Reproduction in the female revolves around changes in ovarian structures and the hormones (Table 5-2) produced by each structure. The cyclic changes in ovarian structures are called the ovarian cycle. Estrus or heat in cows is stimulated by the production of estrogen by a large follicle (Figure 5-2). Follicles are the fluid-filled, balloon-like structures on the ovaries that contain the oocyte (egg). The large amount of estrogen produced by the follicle also stimulates a massive release of luteinizing hormone (LH). This phenomenon is known as the LH surge. The LH surge occurs generally at the same time as the onset of standing estrus and stimulates the rupture of the large follicle (termed ovulation) and release of the oocyte (egg). Ovulation of the large follicle occurs approximately 24 to 36 hours after the onset of standing estrus. During ovulation, the oocyte is released, and the follicle wall collapses and begins to form a corpus luteum (CL). After ovulation, the CL increases in size and increases its production of progesterone. Progesterone inhibits final maturation of ovarian follicles and estrus. Approximately 16 to 17 days after estrus, the uterus releases prostaglandin $F_{2\alpha}$ (PG) that stimulates regression of the CL and a reduction in

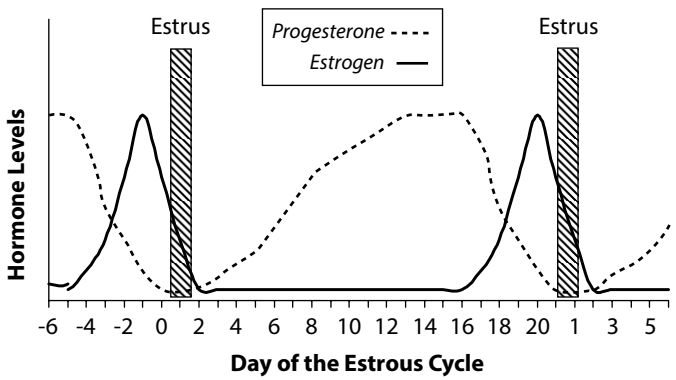


Figure 5-2. Cyclic changes in reproductive hormones.

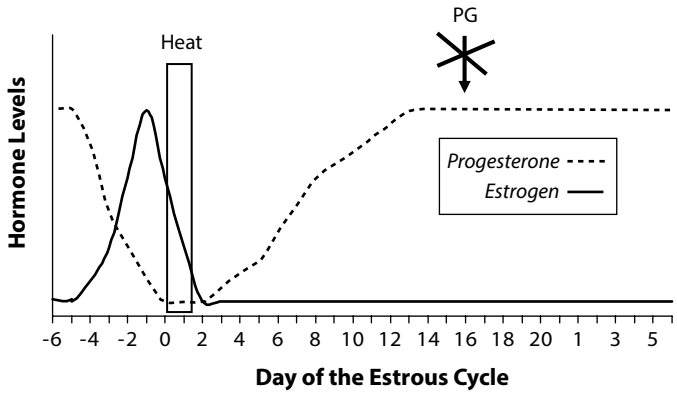


Figure 5-3. Changes in reproductive hormones during pregnancy.

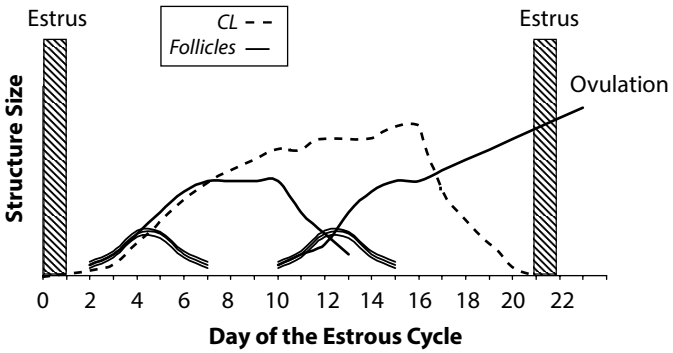


Figure 5-4. Changes in follicle growth—2 waves.

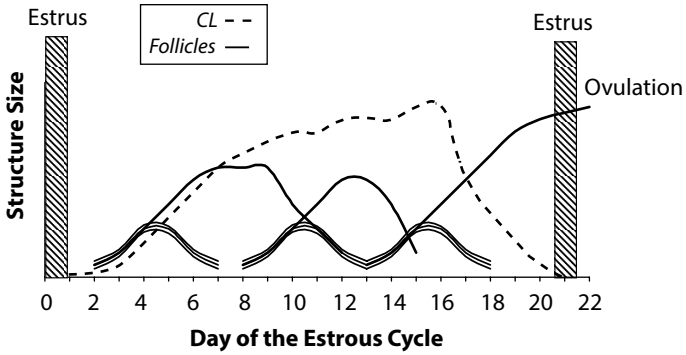


Figure 5-5. Changes in ovarian structures—3 waves.

progesterone production. Declining progesterone production allows final maturation of a large follicle that stimulates the subsequent estrus.

Alternatively, if a cow is pregnant (Figure 5-3), the developing embryo produces hormones that prevent the uterus from releasing PG. If PG is not released, the CL is preserved, and pregnancy is maintained until calving.

Follicles grow and regress throughout the estrous cycle. Follicle growth in cattle occurs in a wave-like pattern, and females generally have either two or three waves of follicular development during an estrous cycle (figures 5-4 and 5-5). A wave of follicular growth is characterized by the initial growth of several small follicles (< 5 mm in diameter). Within a couple of days of emergence, one follicle grows larger than the remaining follicles and is regarded as the dominant follicle. The dominant follicle then suppresses the continued growth of the subordinate follicles, resulting in their regression. The dominant follicle grows until it reaches its maximal size (12 mm to 15 mm). If progesterone concentrations are high, the dominant follicle regresses, and a new wave of follicles begins to grow. Alternatively, if progesterone concentrations are low, the dominant follicle continues to grow until ovulation. Emergence, growth, and regression of a follicular wave generally take eight to 10 days.

Reproductive States

Cows that exhibit regular estrous cycles as described above are usually little problem to breed. Most reproductive management programs are centered on the population of cows that most dramatically affect reproductive efficiency: anestrous cows. Anestrous females are those that have not yet begun to exhibit regular estrous cycles. Anestrus occurs every year of a female's productive life. The first period of anestrus occurs prior to puberty. After females have reached maturity, they exhibit periods of anestrous after every calving. The reproductive activity of cows after calving is shown in Figure 5-6. After calving, cows are anestrous for a variable period of time. The time period from calving to the resumption of estrous cycles, called the postpartum interval, can range from 17 days to 180 days. The average length of the anestrous period in mature (> 4 years of age) cows in adequate body condition (5 or greater) is 60-70 days. The length of the postpartum interval is regulated by age, nutritional status, calving difficulty, calving season, and genetic makeup. To maximize the opportunity for profit, cows need to be reproductively efficient and most research indicates that reproductively efficient cows maintain a 365-day calving interval. To maintain a 365-day interval, a cow needs to rebreed within 80 days of calving. Cows with long periods of anestrus struggle to maintain a profitable 365-day calving interval.

The transition from anestrus to estrous cycles is preceded by the occurrence of an abnormally short estrous cycle—seven to 14 days (Figure 5-6). The "short cycle" occurs in most (80 percent) anestrous females that are transitioning to estrous cycles. Estrus does not normally occur prior to the short cycle and is nonfertile (Figure 5-7). Fertility increases until the second estrus after the short cycle.

The proportion of cows that are anestrous on the first day of the breeding season regulates reproductive success. Current research has demonstrated that approximately one-half of all cows are

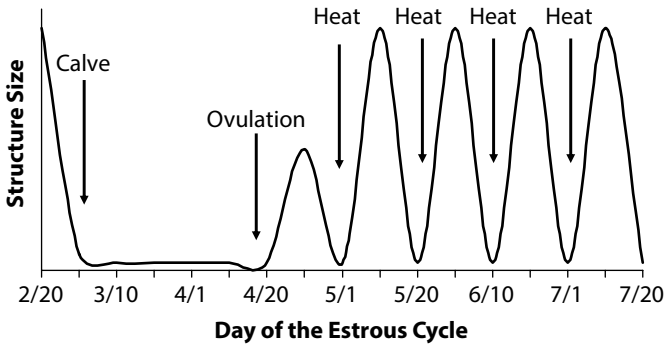


Figure 5-6. Postpartum (after calving) reproductive activity.

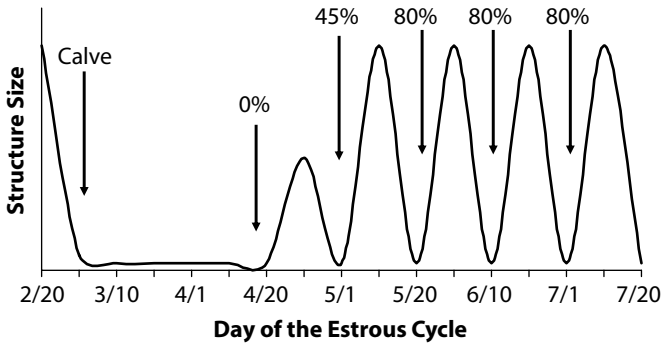


Figure 5-7. Changes in fertility after calving.

anestrous on the first day of the breeding season. However, the percentage of cows that were anestrous on the first day of the breeding season ranged from only 20 percent to as high as 83 percent. Logically, methods to reduce the incidence of anestrus in the cowherd will increase the opportunities of conception.

Estrous cycles can be induced in anestrous cows. The most successful method of inducing anestrous cows to initiate estrous cycles is to administer progesterone. Two sources of progesterone are available for use by producers. The first is an orally active, synthetic form of progesterone called melengestrol acetate (MGA). The best source of progesterone for inducing anestrous cows is the CIDR® (Controlled Internal Drug Release) device (discussed later). Cows exhibit estrus once the CIDR® device is removed or the MGA feeding is stopped. Typically, anestrous cows are treated with a CIDR® or MGA for seven days to induce estrous cycles. Treatment of anestrous cows with either a CIDR® device or MGA can induce estrus in approximately 80 percent of all anestrous cows.

Reproductive Management of the Beef Cow Herd

The first step in reproductive management of the herd is to determine when to calve. Choose the time of year for calving that is best for your operation. Most Kentucky producers choose spring calving because it fits with their pasture programs. However, fall calving is most favorable in terms of weather.

Spring Calving (March-May)

Most cows calve in the spring. Many cattle producers prefer spring calving because input costs are lower; cows can be wintered with less harvested and poorer quality feed because they are "dry" during the winter. Calving in the spring has several disadvantages. Spring calves generally are born during the wettest season, when it is frequently cold. Poor weather at calving can lead to increased calf sickness and death. Rebreeding is more difficult when cows calve in the spring. Heat stress caused by consumption of endophyte-infected fescue can be a problem during the latter part of the breeding season (July-August) of spring-calving cows. The conception rate of cows experiencing heat stress is only 30-35 percent (normal conception rate for Kentucky is 60-70 percent). Overall, the reproductive rate of cows that calve in the spring is lower than fall or winter calving. Maximizing the marketing value of spring-born calves is also more difficult due to the number of calves flooding the market each fall and winter (for more information on seasonal prices for calves, see Chapter 10: Marketing).

Fall Calving (September-October)

Calving in the fall has many advantages over spring calving. Cows are usually in better condition, and the weather at calving and breeding is more favorable. Cows that calve in the fall have smaller calves, a lower incidence of dystocia, and better colostrum. Calf sickness and death rates are lower for fall calving cows. Stockpiled/accumulated fescue can be used effectively during the breeding season. Endophyte-infected fescue is less of a problem in the breeding season of fall-calving cows than that of spring-calving cows. Cows resume estrous cycles earlier after calving in the fall, have a higher conception rate, and more cows become pregnant over a short time period. Fall calves offer some flexibility in marketing: they can be sold at weaning or grazed for a period of time. The market for fall-born calves is usually better than for spring-born calves. However, more stored feed of higher quality is required to meet the nutritional requirements for the fall-calving herd because cows are in lactation and must rebreed during the winter.

Winter Calving (January-February)

Winter calving occurs during the coldest part of the year, which means you must pay more attention during the calving period. The calves have heavier weaning weights for fall marketing than spring-born calves. The cows require ample amounts of feed in February and March if they are to rebreed on time. Calf disorders such as scours and pneumonia may be a problem.

Rationale for Controlled Calving Season

The second step in reproductive management is controlling the calving season. Whichever calving season (spring, winter, or fall) is chosen, the following reasons illustrate why a controlled, seasonal calving schedule is desirable:

- The culling of cows and selection of replacements are based on production records; however, accurate comparisons of the production of cows within a herd cannot be made unless a certain degree of uniformity exists among their calves. Decisions to keep or cull cows should reflect relative performance of calves within the herd. Acceptable performance implies not only weaning weight but also that a cow produces a calf every 12 months.
- Shortened calving seasons provide a better opportunity to offer improved management and observation of the cow herd likely resulting in fewer death losses at calving (a major source of reproductive failure among any herd of cows). This is vital because percent calf crop weaned is one of the major profit-determining factors in a cow-calf operation.
- Shortened calving periods facilitate improvements in herd health and management. Uniformity in timing of vaccinations and routine management practices result in decreased labor requirements and enhanced efficiency. Calving in controlled seasons aids in accurate pregnancy testing and culling of open cows which can reduce feed expense and improve herd efficiency.
- Brood cow nutrition can be improved by grouping cows according to stage of gestation and feeding each group accordingly. When cows are strung out in their expected calving dates, some cows may be over/under fed making it difficult to provide adequate nutrition to cows in a cost-effective manner.
- Calf crops that are uniform in age and size can be marketed in groups. Marketing groups of calves generates premiums compared to marketing single calves, (see Chapter 10: Marketing) which increases revenue and profit potential. Calves born in the first 21 days of the calving season can weigh 30-50 pounds more at weaning than those born during the second 21-day period. Calves born 42 days into the calving season have been found to weigh as much as 70 pounds less than those born in the first 21 days and 42 pounds less than calves born in the second 21 days.

- A research analysis of 394 ranch observations from the Texas, Oklahoma, and New Mexico SPA (standardized performance analysis) data set provided insight into the age-old argument about "leaving the bull out" or having a defined breeding season. Oklahoma State University and Texas A&M agricultural economists (Parker, et al) presented a paper at the 2004 Southern Association of Agricultural Scientists. They found a positive relationship between number of days of the breeding season and the production cost per hundredweight of calf weaned. Also they reported a negative relationship between number of days of the breeding season and pounds of calf weaned per cow per year.

The data suggested that for each day the breeding season was lengthened, the annual cost of producing a hundred pounds of weaned calf increased by 4.7 cents and pounds of calf weaned per cow per year decreased by 0.158 pounds. The range of breeding seasons in the data set was from extremely short (less than one month) to 365 days or continuous presence of the bull. The trend lines that resulted from the analysis of the data give us an opportunity to evaluate the economic importance of a defined breeding season. The producer that leaves the bull out year-round (365 days) would sell 45.82 fewer pounds of calf per cow per year on the average than producers with a 75-day breeding season. That same producer would have $13.63 greater costs per *hundredweight* of weaned calf than the producer that used a 75-day breeding season. In this era of cost/price squeezes, a well-defined breeding and calving season provides a better opportunity to survive the volatility of cattle prices and input costs.

Hence, shortening the calving season results in:

- Heavier, more uniform calves at weaning
- Better use of available labor
- Better opportunity to select for fertility in the cow herd
- Greater income potential

The best tool to shorten and manage the breeding and calving season is estrous synchronization.

Converting from Year-round to Controlled Calving

Converting from a year-long breeding season to a shortened 2-3 month breeding season should not be done haphazardly.

A system for converting from year-round to a 75-day controlled calving season over a period of two years would present less loss and fewer problems than to try to convert in one year. The following steps are suggested for getting on a controlled breeding system:

- Determine the ideal time of year and the length of your new calving season. For example, cows will calve from March 1 to May 10 (71 days).
- Pull the bull. You cannot gain control of the calving season with the bull in the pasture with the cows. Either sell him or build a strong bull pen or well-fenced bull pasture. An electric fence in addition to the regular fence may be needed.
- Determine the reproductive status of each cow in the herd. First, go to your record book to determine the last date each cow calved. If you don't keep records, try to match the cows and calves up and estimate their age. For example, let's assume we have 30 cows and today's date is January 18, 2019. Calving dates for 2018 are as follows: Jan = 0 calved, Feb = 3 calved, Mar = 9 calved, Apr = 5 calved, May = 5 calved, June = 2 calved, July = 1 calved, Aug = 0 calved, Sept = 2 calved, Oct = 2 calved, Nov = 1 calved, Dec = 0 calved. The bull has been in the entire time so the cows that calved last spring are most likely getting ready to calve in Spring 2019 and the five cows that calved in the fall could be pregnant. Next, work with your veterinarian to determine the pregnancy status of the herd. When will the spring cows calve? Are the fall-calvers open or pregnant? The cows that calved in October and November may not have conceived yet so they can roll easily into your spring-calving system.
- Based upon the reproductive status of your herd, determine if you would like one controlled calving season or two. In our example, we only have six cows calving in the fall window (July-Nov) so having two seasons doesn't really make much sense. If, however, half of your herd calved July-December, it is a better economic decision to make these your fall-calving cows and the ones that calve from January-June your spring-calving cows.
- Identify cows are going to be "problem" breeders. Problem breeders are those cows that are anticipated to be anestrus at the start of the breeding season. These cows include all two-year-old cows (first-calf heifers) and any cow that calves within 45 days of the starting of the breeding season. Thin cows are also a problem regardless of when they calve. If cows calved thin (body condition score < 5), they need to be separated and fed to gain weight at least through the first 30 days of the breeding season.
- Identify cows are going to be "extreme problem" breeders. Extreme problem cows are those that are anticipated to be anestrus for more than half of the upcoming breeding season. These are mainly cows that either calve right before or during the breeding season. These cows need to be managed separately from the breeding herd if at all possible.
- Create a plan to improve the reproductive performance of your cows.
  - » All cows need to be fed to maintain or increase body condition score (slightly) and need to be vaccinated (respiratory viruses, lepto, vibrio, etc.) and dewormed. Vaccination against abortifacients needs to occur at least 28 days before the breeding season.
  - » Early-calving mature cows need no additional management. Just turn them out with the bull at the start of planned breeding season.
  - » "Problem cows" need to receive a CIDR® device or be fed MGA for 7 days immediately prior to bull turn out (see section *Estrous Synchronization Protocols for Natural Service* below. Results from UK field trial work in over 300 late-calving cows suggests exposure of cows as early as 14 days after calving can improve the rebreeding performance in 80 percent of females treated. The average shift in calving interval was 36 days earlier.
  - » "Extreme problem" cows need to receive a CIDR® device for 7 days immediately prior to turning them with

a bull. Group the cows so that they receive a CIDR® device at least 14 days after calving. Thus, cows calving during the planned breeding season would receive a CIDR® device for 7 days immediately before transporting them to the breeding pasture.

- Plan your breeding season. For example, a cow that calved in November was open when the bull was removed. She will be rolled to the spring with the cows that will calve from January-July. A decision will need to be made for the August-October calving cows. Do we cull and replace them or do we hold them after they calve this year? Remember, they were pregnant when reproductive status was determined in Step 3 so we have to either cull and replace or wait on them to calve and hold them over until the spring of 2020. Typically, it is a little cheaper to simply hold the cow over because the "cost" of this decision is the loss of 4-6 months of potential revenue ($200-$400). If the cow is older (8+ years) then consider culling her and replacing with a bred heifer that will calve in February. The cost difference between a bred replacement heifer and a cull cow is about $500 but that is highly variable. Recently, cull cows have been really cheap so the cost to replace is a bit higher.
- Expose your herd to the bull on May 20 and remove the bull September 1st in this example. This is later than ideal but the process to move from year-round calving to controlled-calving is normally a two-year process. Sixty days after removing the bulls from the herd (or at a convenient time near this date), pregnancy check all cows and cull open cows. Your fall-calving cows have likely either calved or are very close to calving.
- If you are developing your own replacements, consider starting the breeding season of replacement heifers 20 to 30 days ahead of the final breeding date for the herd. Most extended calving seasons are the result of failure of young cows to rebreed in a timely fashion. The additional 20-30 days enhances the opportunity for these young cows to rebreed next season. So, the replacement heifer breeding season would start around April 20 and these females would begin calving around February 1. Weather in February is not always ideal calf death loss might increase 1-2 percent. Financially, 1-2 percent death loss is easier to swallow than a 25 percent decrease in pregnancy rate the following year.
- The second year, follow the same system as outlined above except remove the bull on August 1. If you have fall and spring calvers, then put the bull in for the fall cows around November 20 and remove him around February 1.

Data currently being collected by the University of Kentucky Beef IRM group demonstrates that following this step-wise plan for reproduction can improve pregnancy rate by 6 percent and increase the pounds of calf weaned per cow exposed to the bull by about 150 pounds (more calves born, wean more at marketing). Revenue on these farms increased by 34 percent even in today's market. Controlling reproduction pays regardless of the market.

Example of Implementing a Plan to Control Calving

The IRM Farm Program was designed by the UK Beef IRM team to increase the use of production practices favoring high reproductive rates in the cowherd. This program is delivered through on-farm instruction to demonstrate the benefits of implementing these production practices.

Below is an example of controlling the calving season from one of the farms enrolled in the IRM Farm Program This producer managed a small herd of Limousin-influenced cattle and, before joining the program, the cowherd did not calved in a defined calving season. Because of his other farm obligations, this producer targeted a fall calving season beginning in September.

Table 5-3. Results on transitioning to a controlled calving season.

	2015	2016	2017	2018
Total Cows	17	13	17	24
# Cows Calved	15	12	15	21
Calving %	88%	92%	88%	88%
# Cows Weaned a Calf	13	12	15	20
% Weaned / Cow Exposed	71%	92%	82%	83%
Total WW (lbs)	5281	5184	6270	9414
WW / Cow Exposed (lbs)	311	399	369	392
Date of First Calf	1/14/15	9/10/16	8/26/17	8/15/18
Date of Last Calf	12/22/15	11/9/16	10/11/17	10/2/18
Calving Season Length (d)	342	60	46	48
% Calved in Desired Window	56%	100%	100%	100%
AI %	0%	50%	75%	59%

The results from this operation over the last four years are depicted in Table 5-3. The first step was to sell the bull. In order to control the calving season, we need to control the breeding season therefore our first step was to remove the bull from the cowherd. The second step was to assess the reproductive status and fitness of individual cows in the herd and develop a management plan. During the fitness assessment, six cows were determined to be inadequate for various reasons that included: age, feet/leg problems, and failure to have a calf and were sold in 2015. Two open replacement heifers were purchased.

In the first year of the program, the cows that calved in the spring of 2015 were held open until the fall breeding season. In 2015, only 56 percent of the cows calved in the desired window. The producer was interested in the benefits of using estrous synchronization and AI. In the first breeding season in the program, 12 cows were bred using a timed-AI protocol. To help her advance in the calving season, one late-calving cow that received a CIDR® device for seven days beginning 14 days after calving. She was exposed to the bull after the CIDR® device was removed. Half of the females conceived to the AI, 12 of the 13 cows weaned a calf, and 100 percent of the herd calved in the desired window. The 2016 calving season took place in a 60-day window, beginning September 10 and ending on November 9.

In 2016, the producer added a few replacement heifers, increasing his herd size to 17 total breeding age females. Pleased with the first-year results, he wanted to implement estrous synchronization and AI again. In the fall of 2017, 75 percent conceived AI and 15 of the 17 females calved from August 26 to October 11; a 46-day calving season. The two cows that failed to conceive were sold and seven replacement heifers were retained. In 2018, 59 percent conceived AI and 21 of the 24 cows calved during a 48-day window. These cows weaned 20 calves that weighed 9,414 pounds total, equaling 392 pounds of calf weaned per cow exposed to breeding.

Cows are evaluated before each breeding season for soundness. In 2018, seven cows were culled because of infertility, poor feet/legs, udder quality, size, age, and were replaced with seven purchased bred heifers. All breeding-age females were subjected to a timed-AI protocol in the fall of 2018. Results from the pregnancy diagnosis this spring indicate that all but one cow conceived, almost 60 percent conceived to the AI, and all conceived in a short time period. Weaning weight per cow exposed to the bull increased 82 pounds (310 lb. to 392 lb.) from 2015 to 2018. Weaning weight was not adjusted for cow age. Using an average market value (average of steer and heifer) for a 300 lb. calf ($188/cwt) and 400 lb. calf ($176/cwt), this 82-pound increase equates to an additional revenue of $104 per cow.

These numbers are just a snapshot at the progress that has been made. The calving season length decreased, productivity increased, and production efficiency increased. The changes were the result of the producers desire to improve and his willingness to make changes, and adopt production practices favoring high reproductive rates. The cowherd is not recognizable compared to the start of the program. This producer now has a herd with improved disposition, feet/leg structure, and udders quality. Cow size has decreased, weaning weights have increased, a stringent health program and estrous synchronization and AI have been implemented, and a condensed calving seasons has been maintained. Additionally, the behavior of the producer has completely changed. He has a herd to be proud of and enjoys his cattle enterprise.

In summary, the results are truly incredible. The calving season length has been shortened from 342 days to less than 60 days. The pounds weaned per cow exposed increased over 80 pounds. This reduction in calving season length was possible through controlling exposure to the bull and implementing an estrous synchronization program and AI.

Reproductive Techniques

Artificial Insemination

Successful artificial insemination (AI) breeding programs depend on adequate facilities, good herd health programs, sound nutritional management, and experienced, well-trained technicians responsible for detecting estrus and insemination. Most problems and failures in AI programs are associated with poor nutritional development in replacement heifers, inadequate body condition of cows after calving, failure to identify cows in heat, and/or failure to breed cows at the proper time. Rarely is infertility the result of poor quality semen or technician error.

Heat Detection

Accurate heat detection and record keeping are perhaps the most time-consuming and least-interesting jobs associated with an AI program. However, in many respects, they are the most important to the overall success rate. Heat detection requires skilled observation, patience, and a general familiarity with the reproductive processes of cattle. Data from Colorado State University demonstrate the importance of accurate heat detection. In this trial, cows were observed for estrus either twice daily, four times daily, or continuously. As heat detection intensity increased, conception rates to AI were 67 percent, 75 percent, and 90 percent. Inadequate heat detection can affect herd profitability in the following ways:

Figure 5-8. Cow in standing estrus.

- Undetected heats result in longer calving intervals and decreased weaning weights of calves.
- Breeding cows that are not ready to be inseminated results in decreased conception rates and wasted time and semen. (See Figure 5-9 for the best times for breeding to occur.)
- Inseminating already pregnant cows that were mistakenly identified as being in heat can result in abortion.

Standing to be mounted is the sign of heat that is most accurate in selecting cows for insemination. Because pregnant cows will on occasion exhibit heat, it is important to keep thorough records and use a skilled technician.

The efficiency of heat detection may depend on the proportion of animals in heat at the same time. This is usually not a problem in larger herds but may present problems in smaller herds. Synchronization of estrus becomes a valuable alternative in these situations.

Other physical and behavioral signs that may signal that a cow is either coming into heat or actually is in estrus include mounting of other cows (Figure 5-8), swelling of the vulva, strands of mucus discharged from the vulva, chin resting, and sniffing and licking of the vulva of other cows.

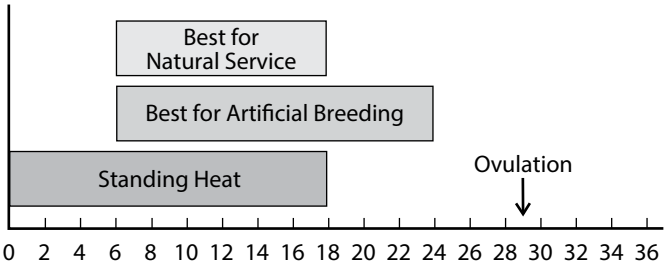


Figure 5-9. Best times for breeding relative to the start of estrus.

Figure 5-10. Proper placing of estrus detection patch. Courtesy of Estrotect, Inc.

Observation	Vigorous Visual Observation	Bull	ESTROTECT™ Heat Detectors
% identified correctly	**92% (83/90)**	**92% (34/37)**	**91% (82/90)**
% identified incorrectly	8% (7/90)	8% (3/37)	9% (8/90)
% suspect	2% (2/90)	3% (1/37)	2% (2/90)
% identified in standing estrus	97% (67/69)	100% (34/34)	97% (66/68)
% identified in standing estrus that ovulated (including ovulated animals)	97% (69/71)	100% (35/35)	97% (68/70)

South Dakota State University, 2005.

Figure 5-12. Accuracy of estrus detection patches. Source: Estrotect, Inc.

Figure 5-11. Example of an estrus detection patch. Courtesy of Estrotect, Inc.

Cows that are isolated or with cows that are not sexually active may exhibit signs of estrus that include hyperactivity and movement, bellowing, tail raising and switching, and frequent urination. Extremes in weather, including periods of extreme cold or heat, can disrupt or diminish estrual behavior and make accurate heat detection difficult.

Heat detection can be assisted through the use of estrous detection patches or electronic devices. Estrotect was one of the first estrous detection patches available for use. The estrous detection patches are placed perpendicular to the spine on the highest part of the tail head (see figures 5-10, 5-11, 5-12). The patches adhere more tightly when the skin is dry and the temperature is above 50°.

Electronic devices can also give a real-time assessment of a cow estrual activity.

Semen

Semen storage. Frozen semen is stored in plastic straws maintained in liquid nitrogen (320°F). Semen should be transferred from one container to another carefully and swiftly (the transfer should be completed within 10 seconds). Semen tanks should be routinely checked to determine if the level of liquid nitrogen is sufficient to ensure proper storage of semen.

Semen thawing. Frozen semen should be thawed in a warm water bath at 95°F for a minimum of 30 seconds. Extreme water temperature can kill the sperm. It is important to routinely check the accuracy of the thermometer used to determine water temperature.

Insemination procedure. Use semen within 20 minutes of being thawed. Once the semen is thawed, the straw should be removed from the thaw bath and thoroughly dried with a paper towel. In loading the gun, the straw should be cut straight across on the crimped end of the straw. The model of French gun determines the type of sheath used. Thawed semen should be protected against temperature shock, preferably by wrapping the front end of the gun with a paper towel.

Semen deposition. Once the external genitalia have been wiped clean, the inseminating rod may be inserted into the reproductive tract. It is important that the cervix be worked over the rod and not vice versa. To ensure proper placement of semen in the body of the uterus, the tip of the technician's index finger should run over the front edge of the cervix to enable the technician to feel the tip of the gun as it protrudes into the uterus (Figure 5-13). Placement too far into the uterus may result in damage to the uterine lining. Research has clearly shown that the body of the uterus is the preferred site of semen deposition. However, semen may be deposited in the cervix on second and later services. This is to prevent disrupting pregnancy if a pregnant cow is accidentally reinseminated.

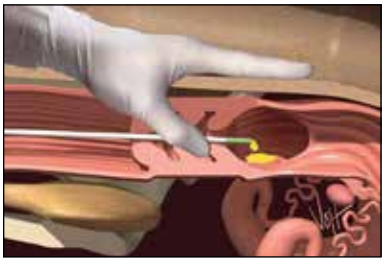


Figure 5-13. Deposit semen into the uterine body. Courtesy of Select Sires, Inc.

Estrous Synchronization

Requirements for the Control of Estrus

One of the major limitations in effectively synchronizing estrus in beef cows is that most postpartum beef cow herds consist of both anestrous and cyclic cows. Thus, for a system to effectively control estrus in all cows, it must: (1) induce death of the CL, (2) control follicular growth, and (3) induce estrus and ovulation in both "problem" and "extreme problem" cows. Problem cows are those that are nearing the spontaneous resumption of estrous cycles, while extreme problem cows are several weeks from initiating estrous cycles. A good example of an extreme problem cow is a first-calf heifer, in moderate to thin body condition and only 30 days after calving. The goal, then, is to develop a system that can be delivered to all cows and result in a synchronous, fertile estrus in most cows (>70%) in the first one to four days of the breeding season.

Products Available for Use for Estrous Synchronization

Several pharmaceutical products are available for use to synchronize estrus in beef cattle. These products can be categorized as prostaglandins, progestins, or gonadotropin-releasing hormones. These products are described in Table 5-4. All hormones used to control estrus must be administered intramuscularly. It is best to administer the drugs with an 18-gauge, 1½-inch needle.

The products used to control estrus are differentially effective according to the two reproductive states; cyclic and acyclic (anestrous). Prostaglandins and GnRH are used predominately to synchronize cyclic cows. Prostaglandins stimulate regression of the corpus luteum (CL) and anestrus cows do not have a CL so prostaglandins have no or a very limited role. GnRH stimulates follicle rupture, formation of a CL, and recruitment of a new follicle wave. Both reproductive classes of cows have growing follicles but GnRH is only effective when a cow has a follicle that is about 10 mm in diameter. GnRH is typically injected at the beginning and end of most estrous synchronization protocols. Studies have shown that GnRH is effective 10-80 percent of the time when used at the beginning of the protocol so its usefulness if injected alone to anestrous cows is also limited. Progestins (MGA and CIDR® devices) are most effective for synchronization of estrus in anestrous cows. A seven-day progestin protocol alone has limited ability to synchronize estrus in cyclic cows.

In June 2002, the Federal Drug Administration approved the use of the Controlled Internal Drug Releasing (CIDR®) device for use in estrus synchronization of beef females. The CIDR® device is the best source of progesterone available for use. Several systems have been developed that utilize the CIDR® device to synchronize estrus.

A CIDR® is a T-shaped device made of soft pliable plastic that is coated in progesterone. The CIDR® is inserted into the vagina of the cow, and the progesterone is absorbed into the bloodstream. To insert the CIDR® device, restrain the female, and prepare a container of clean water with a disinfectant solution. Wash the applicator with water between uses. Insert the CIDR® device into the CIDR® applicator by pushing the wings together; keep the tail pointed outward. Apply a lubricant to the end of the CIDR® device, wipe the vagina clean, and insert the CIDR® into the vagina until the device meets significant resistance. Depress the plunger and rotate the applicator approximately one-quarter turn. Best results are obtained when the tail of the device is pointed downward. If significant loss of the CIDR® device is observed (> 5 percent), clip the tail of the CIDR® so that approximately 2½ inches protrude from the vagina (for more information, view this YouTube video: https://www.youtube.com/watch?v=j8ZHjzzuZNg&list=PLC5aJFY_Be8XJZ_03_Ql73TK0826T8Fjq&index=4&t=7s).

Table 5-4. Products used to control estrus in beef cattle.

	Product	Administration	Action
Prostaglandins	Lutalyse	5 ml, i.m.	Regress the corpus luteum
	Prostamate	5 ml, i.m.	
	Estrumate	2 ml, i.m.	
	In-Synch	5 ml, i.m.	
Progestins	MGA	0.5 mg/head/day	Imitate the corpus luteum
	CIDR	7 days intravaginally	
Gonadotropin-releasing hormone (GnRH)[a]	Cystorelin	2 ml, i.m.	Causes formation of a corpus luteum
	Fertagyl	2 ml, i.m.	
	Factrel	2 ml, i.m.	
	Ova-Cyst	5 ml, i.m.	
Estrogens	Estradiol Cypionate	0.5 ml, i.m.	Stimulate heat and release of egg

[a] Keep refrigerated.

Estrous Synchronization for Artificial Insemination

General

Following is a brief discussion of the preferred protocols to synchronize estrus in heifers and cows. The protocol sheet developed by the Beef Reproduction Task Force is included for reference.

Heifer Systems

Synchronizing a fertile estrus in yearling heifers is a challenge. Two factors limit conception rate to AI in heifers; puberty and follicle growth. Most systems discussed will induce puberty but controlling follicle growth to effectively synchronize a fertile estrus and ovulation is difficult.

Long-term Protocols

MGA-PG

The most reliable and proven protocol for synchronizing estrus in beef heifers is the MGA-PG system (see Figure 5-14). This system was developed in 1988 and works very well. The biggest problem with this system is it is not suitable for a fixed-time AI.

The most common progestin used to synchronize estrus in beef females is melengestrol acetate (MGA). MGA is an orally active, synthetic progestin that effectively suppresses estrus when fed at a rate of 0.5 mg/head/day. In this system, MGA is administered for 14 days and prostaglandin is administered 19 days after the last day of MGA feeding. Administration of the MGA-PG system synchronizes estrus in most cyclic females and can induce estrus in most anestrous females. Also, after the long-term MGA feeding, females are between days 10 and 15 of the estrous cycle when PG is administered, thus ensuring that PG is maximally effective in stimulating the regression of the CL. Administration of the MGA-PG system to females usually results in estrus in approximately 80% to 100% of females. Since fertility is normal in this system, pregnancy rates usually range from 45% to 70%.

The biggest disadvantage to the use of the MGA-PG system is that it takes 39 days to complete and requires consistent intake of MGA. The MGA is normally supplied to the females as a supplement to normal prebreeding diets and should be fed at a rate of 0.5 mg/head/day. It is imperative that all females consume ad-

equate levels of MGA. Therefore, at least 2 feet of bunk space is necessary to ensure that even timid females have access to feed. Producers should also observe feeding to ensure that all females are consuming the MGA supplement. The most common failure of the MGA-PG system lies in consistent, adequate consumption of MGA.

14 CIDR® - PG

A CIDR® device can replace MGA in this system. The 14-Day CIDR®-PG protocol involves inserting a CIDR® device for 14 days. Prostaglandin is administered 16 days after the CIDR® device is removed. Heifers can then be observed for estrus and bred accordingly.

The number of days of estrus detection can be reduced by injection of gonadotropin hormone-releasing hormone (GnRH; pharmaceutical trade names Cystorelin®, Factrel®, Fertagyl®, Ovacyst®). In this system, estrus should be detected for 72 hours after PG. All heifers in estrus should be inseminated approximately 12-14 hours after first estrus is observed. Heifers not observed in estrus by 72 hours are injected with GnRH and time inseminated 72 hours after PG.

Timed insemination using MGA-PG or 14-Day CIDR®-PG

Many producers simply do not have the labor or facilities to support multiple days of estrus detection and cattle handling. The MGA-PG and 14-Day CIDR®-PG protocols are both suitable for timed insemination. Timed insemination should occur in heifers 72 hours after PG if you are using the MGA-PG system and at 66 hours after PG if you are using the 14-Day CIDR®-PG system. Females are administered GnRH at the fixed-time AI. GnRH is only necessary for females that are NOT in estrus. Therefore, if cows were observed for estrus or if estrous detection aids are used, then GnRH is only given to females that have not yet been in estrus. If cows were not observed or an estrus detection aid used, then all females need to be injected with GnRH at fixed-time AI. Conception rates to timed insemination are higher when using the 14-Day CIDR®-PG protocol than the MGA-PG protocol (Figure 5-15).

Short-term Protocols for Heifers

7-Day Co-Synch + CIDR® and the 5-Day CO-Synch + CIDR®

One of the major drawbacks to using the MGA-PG and 14-Day CIDR®-PG protocols is the length of time (33-39 days) from the beginning to the end of treatment. Two short-term protocols have been developed for use in heifers that have both proven effective. These two protocols are the 7-Day CO-Synch + CIDR® and the 5-Day CO-Synch + CIDR® (Figure 5-16).

Both of these systems begin with insertion of a CIDR® device and an injection of GnRH (Day 0). The CIDR® is removed and PG given 7 (Monday-Monday) or 5 (Monday-Saturday) days later. A second injection of PG is needed when using the 5-Day CO-Synch + CIDR® system. The second injection is administered 6-10 hours after CIDR® removal and the first PG injection. Timed insemination occurs about 54

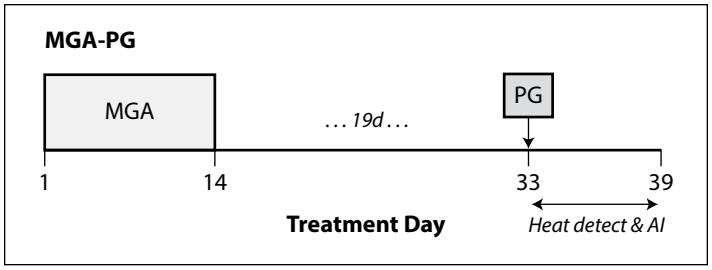


Figure 5-14. MGA-PG protocol.

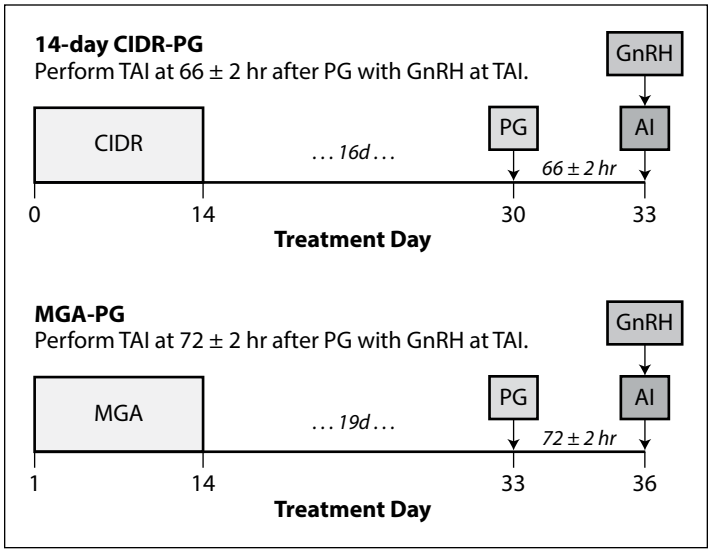


Figure 5-15. 14-day CIDR-PG and MGA-PG protocols.

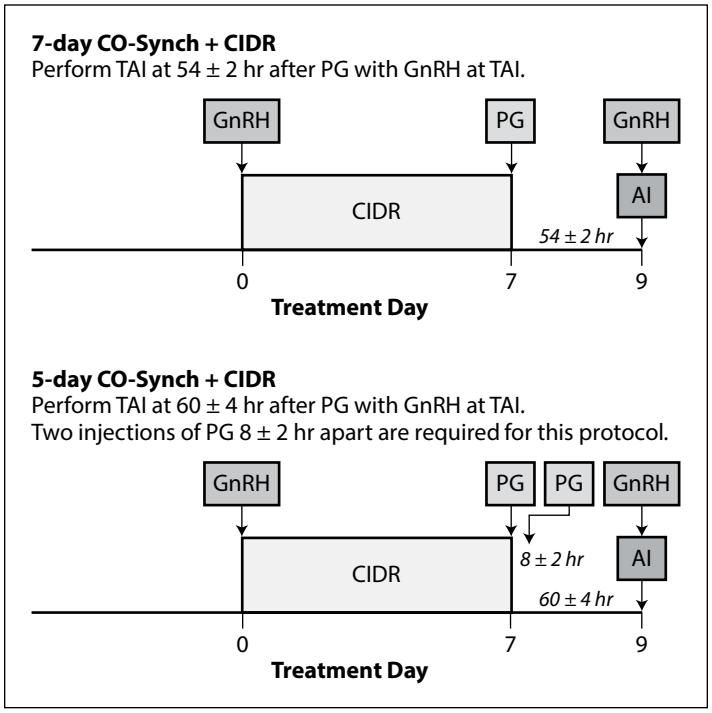


Figure 5-16. 7-day and 5-day CO-Synch + CIDR protocols.

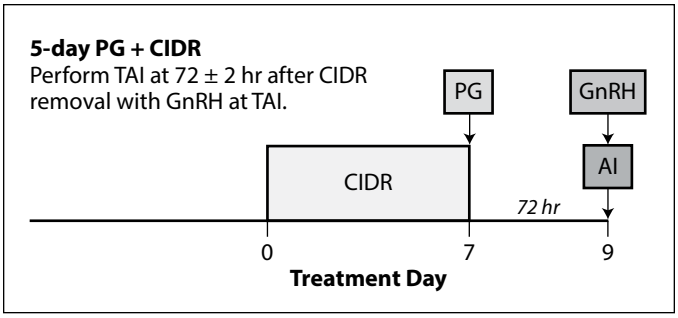


Figure 5-17. 5-day PG + CIDR protocol.

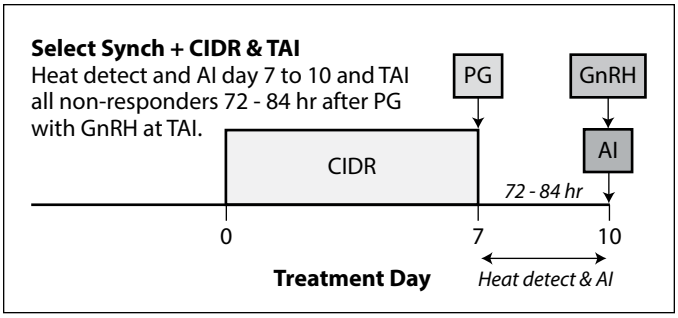


Figure 5-18. Select Synch + CIDR & TAI protocol.

hours after CIDR® removal in the 7-Day CO-Synch + CIDR® protocol and from 60-72 hours after CIDR® removal in the 5-Day CO-Synch + CIDR® protocol; most research actually favors the timed insemination at 72 hours. Recently, the 5-Day CO-Synch + CIDR® protocol has been simplified. Acceptable conception rate to AI can be achieved when a CIDR® is inserted for 5 days and PG administered at CIDR® removal. Females are inseminated 66-72 hours after CIDR® removal. This simplification of the 5-Day CO-Synch + CIDR® protocol needs more research but looks very promising. Approximately 2,000 heifers have been inseminated in Kentucky using the modified 5-day PG + CIDR® protocol (Figure 5-17) since 2015. Conception rates to AI consistently reach 60%. Conception rates to AI are typically higher in heifers using the 5-Day systems compared to the 7-Day protocol.

Cow Systems

Many new systems for controlling the expression of a fertile estrus have been developed in recent years. Beef cow-calf producers have numerous ESAI protocols at their disposal. Many of these protocols can result in acceptable pregnancy rates but vary in cost, effectiveness, and implementation. To determine the appropriate system, producers need to consider several factors: 1) proportion of cows that are anestrus and the calving distribution, 2) available labor, skill, expertise, and facilities for accurate detection of estrus and stress-free handling of cattle, 3) cost of synchronization treatment, 4) value of semen, 5) availability of AI technician, and 6) acceptable level of success. Each of these factors will affect the choice of estrus synchronization protocol. A major consideration affecting the system of choice is labor availability for estrus detection and AI. Systems are available that require complete, limited, or no estrous detection (fixed-time inseminations or TAI).

Select Synch + CIDR® & TAI

Many beef producers have neither the time nor the available labor for adequate estrous detection and the cattle handling necessary for Select Synch. Also, the availability of a quality AI technician is often limited. Thus, many producers desire protocols in which estrous detection is limited (2-3 days) or cows are artificially inseminated at a fixed time (TAI). Select Synch + CIDR® & TAI was developed to reduce the number of days of estrous detection. The Select Synch + CIDR® & TAI begins with an injection of GnRH (100 μg) and insertion of a CIDR® followed 7 days later by treatment with PG and removal of the CIDR® insert.

Producers that want to maximize AI pregnancy rates with limited estrous detection need to use Select Synch + CIDR® & TAI (Figure 5-18). In this system, cows are observed for estrus for 72-84 hours after PG is administered and the CIDR® is removed. Cows observed in estrus are inseminated accordingly. At 72-84 hours, all cows NOT observed in estrus are subjected to TAI and are given a second injection of GnRH. Treatment of postpartum cows with Select Synch + CIDR® & TAI has several advantages: 1) only 3 days of estrous detection, 2) inclusion of the CIDR® prevents early estrus (before PG) and induces estrus in more anestrous cows, 3) results in high AI pregnancy rates. The high AI pregnancy rates are the result of combining the higher conception rates to AI following accurate estrous detection and conception that occurs in some cows that would have been missed using estrous detection alone.

Select Synch + CIDR® & TAI should be used for ESAI if:

- A large proportion of the cows are anestrus before treatment. If cows are a little thinner (BCS 4-5), the herd consists of several young cows, and many of the cows are less than 45 days postpartum, a system that includes a CIDR® is necessary.
- Facilities and labor are available for daily estrous detection and cattle handling for at least 3 days.
- Technician is available twice daily for at least 3 days.

Value of the semen is moderate to high. When the value of the semen is high, conception rate must be maximized. Select Synch + CIDR® & TAI maximizes pregnancy rates to AI but the cost is higher because all cows are inseminated. Conception rate is lower even though the AI pregnancy rate is higher.

- Higher AI pregnancy rates are more important to the producer than the higher costs of the estrus synchronization protocol.

7-Day CO Synch + CIDR®

Producers that desire systems that require NO estrous detection should use 7-Day CO-Synch + CIDR® (Figure 5-19). In this system, all cows are subjected to a second injection of GnRH & TAI anywhere from 60-72 hours after PG is administered. Acceptable AI pregnancy rates can be achieved when GnRH & TAI occurs at any time from 48-72 hours after PG. The highest AI pregnancy rates appear to occur when TAI occurs near 66 hours after PG administration.

Systems that incorporate total TAI are more variable in AI pregnancy rate than systems that use either total or partial estrous detection. The decision to use systems with complete TAI needs to involve

an assessment of your or the producers comfortable level of risk. Systems that use total TAI involve higher risk. Several management factors can reduce the risk involved with systems that use complete TAI. First, cows must be in a BCS ≥ 5 (BCS scale 1-9; 1 = emaciated, 9 = extremely obese) both at calving and at the beginning of treatment. Also, mineral status (i.e. copper and selenium) of the cows can affect pregnancy rate to and many cows in the Southeast are deficient in these two minerals. Second, cows must be at least 30 days (preferably 45 days) postpartum at the beginning of treatment. Third, minimize the number of primiparous cows that are subjected to the TAI protocol. Fourth, cows must have been previously vaccinated and dewormed at least 28 days before AI. Success is possible using TAI systems if the risk factors are minimized.

7-Day CO-Synch + CIDR® & TAI should be used for ESAI if:

- Facilities and labor are NOT available for daily estrous detection and cattle handling.
- Technician availability is very limited.
- Value of the semen is low to moderate. When the value of the semen is high, conception rate must be maximized. CO-Synch + CIDR® & TAI reduces conception rates to AI and the cost is per pregnancy is higher because all cows are inseminated. Semen of high value should not be used.
- Pregnancy rates of anestrous cows to this system have been acceptable but low. Reducing the proportion of anestrous cows will reduce the risk associated with TAI protocols.

Resynchronization of Estrus

The CIDR® device can also be used to synchronize the return heats in females previously subjected to estrus synchronization and AI. To resynchronize heats (Figure 5-20), a CIDR® device is inserted 14 days after the previous synchronization period. Seven days later, the CIDR® device is removed. Estrus is observed and females inseminated over the next three days. Preliminary data using Resynch appear excellent. In this trial, females were synchronized using Select Synch plus a CIDR® device and then resynchronized using a CIDR® device. Only 32% of all females treated returned to estrus and were re-inseminated. Most females were observed in heat 24 to 48 hours after CIDR® removal. The conception rate to the AI was excellent and averaged 60%. Thus, after two estrous synchronization periods and six trips down the chute, 80 to 85% (average 84%) of all females treated conceived to AI.

Reuse of a CIDR® device is *not* approved by the FDA and is not recommend by its manufacturer. Reuse of the CIDR® devices can lead to increases in vaginal infection that could reduce fertility. Additionally, the concentration of progesterone released by the previously used CIDR® devices may not be adequate for effective estrus synchronization. Unpublished data have demonstrated that the effectiveness of the CIDR® device is reduced in once- and especially twice-used CIDR® devices.

Many cattle producer reuse CIDR® devices. If a CIDR® device is to be reused, care must be taken to ensure that the device is clean. Immediately after removal, wash the CIDR® devices with a limited amount of water and a soft-bristled brush. *Do not* soak the CIDR® devices. After cleaning, the CIDR® devices should be dipped in a disinfectant, rinsed with clean water, and allowed to dry. The best possible option for reusing CIDR® devices is to get them sterilized using an autoclave. An autoclave uses heat and pressure for sterilization. Many veterinarian offices have autoclaves and may be willing to sterilize CIDR® devices.

Economics of Estrus Synchronization

The genetic reliability with AI is generally greater than with most natural sires. However, less than 10% of the beef cows in the United States are artificially inseminated each year. Many reasons exist for the low rate of implementation of estrus synchronization and AI (ESAI) into beef cow-calf operations. One reason is the extensive nature of beef production. Most cows are pastured in large acreages, and the labor necessary for handling the cows is too great. Additionally, many producers lack adequate facilities to enable safe and easy cattle handling.

Beef production is a minor enterprise on many farms. The income from the beef enterprise in most small and medium-sized operations is secondary to other enterprises or to off-farm income. However, the primary reason for the limited inclusion of ESAI is likely facilities and labor. Little information is available to aid producers in making decisions regarding return on investment and profitability

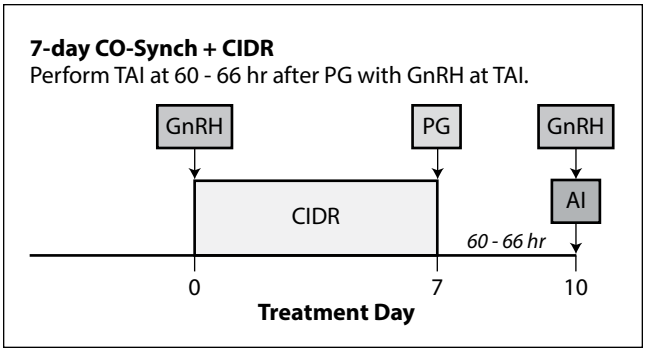


Figure 5-19. 7-day CO-Synch + CIDR protocol.

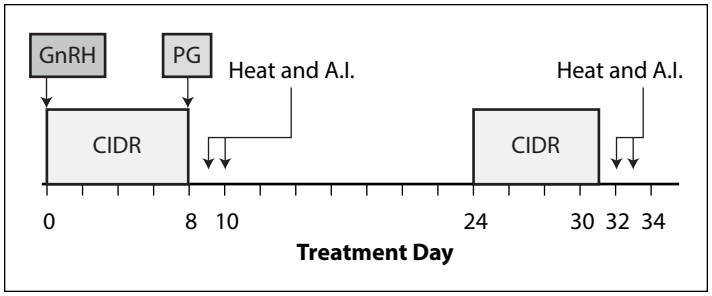


Figure 5-20. CIDR with Resynch.

when considering using ESAI. Many producers may incorporate ESAI if it would improve their profitability both short- and long-term.

Costs per Pregnancy

Few producers understand the costs associated with producing a pregnant female. Sandy Johnson and co-workers from Kansas State University published an excellent article discussing the costs associated with pregnancy using either natural service or a variety of estrus synchronization protocols. Table 5-5 illustrates the costs per pregnancy for bulls that range in price from $1,500 to $5,000 and bull-to-cow ratios from 1:15 to 1:50. Assumptions of the model included use of the bull for four seasons; 10% death loss; 9% interest rate; and an 85% pregnancy rate. Annual bull maintenance costs are variable, and increasing the feed costs by $100 increased cost per pregnancy from $2.22 to $7.41 for high and low bull-to-cow ratios, respectively. Costs per pregnancy ranged from $15.98 to $90.51, depending predominantly on the purchase price and bull-to-cow ratio. Certainly, the ability to identify bulls with a high serving capacity could reduce costs associated with impregnating females.

Table 5-5. Effect of changing pregnancy rate on breeding cost per pregnant female in a Select Synch protocol.

Calving Herd Size	AI Pregnancy Rate (%)	No. of Bulls for Natural Service	Breeding Cost ($) per Pregnancy	Proportion % of Total Cost Attributed To:			
				Bulls	Semen	Labor	Treatments
100	75	1	42.06	20	37	19	15
100	55	2	46.08	37	24	18	14
100	48	3	53.01	48	19	15	12
300	65	5	40.90	35	33	11	16
300	55	6	41.49	41	27	11	15

Source: Adapted with permission from Johnson et al., 2003. Kansas State University Cattleman's Field Day 2003. Pub. No. SRP908.

Table 5-6. Cost per pregnancy using natural service.

Purchase price		$1,500.00	$1,700.00	$2,000.00	$2,300.00	$2,500.00	$3,000.00
Salvage value		860.00	860.00	860.00	860.00	860.00	860.00
Summer pasture		104.13	104.13	104.13	104.13	104.13	104.13
Crop residue		7.50	7.50	7.50	7.50	7.50	7.50
Hay		90.61	90.61	90.61	90.61	90.61	90.61
Protein, mineral		25.00	25.00	25.00	25.00	25.00	25.00
Labor		50.00	50.00	50.00	50.00	50.00	50.00
Vet		21.00	21.00	21.00	21.00	21.00	21.00
Repairs		31.00	31.00	31.00	31.00	31.00	31.00
Misc.		7.00	7.00	7.00	7.00	7.00	7.00
Interest		15.13	15.13	15.13	15.13	15.13	15.13
Total variable		351.37	351.37	351.37	351.37	351.37	351.37
Depreciation on equipment		12.39	12.39	12.39	12.39	12.39	12.39
Depreciation on bull		160.00	210.00	285.00	360.00	410.00	535.00
Interest on bull		212.40	230.40	257.40	284.40	302.40	347.40
Death loss		15.00	17.00	20.00	23.00	25.00	30.00
Total fixed		399.79	469.79	574.79	679.79	749.79	924.79
Total cost/year		751.16	821.16	926.16	1,013.16	1,101.16	1,276.16
Purchase price		$1,500.00	$1,700.00	$2,000.00	$2,300.00	$2,500.00	$3,000.00
	Cows Exposed per Year	**Cost per Pregnancy ($)**					
	15	53.27	58.24	65.69	73.13	78.10	90.51
	20	39.96	43.68	49.26	54.85	58.57	67.88
	25	31.96	34.94	39.41	43.88	46.86	54.30
	30	26.64	29.12	32.84	36.57	39.05	45.25
	35	22.83	24.96	28.15	31.34	33.47	38.79
	40	19.98	21.84	24.63	27.42	29.29	33.94
	50	15.98	17.47	19.71	21.94	23.43	27.15

Source: Reprinted with permission from Johnson et al., 2003. Kansas State University Cattleman's Field Day 2003. Pub. No. SRP908.

Use of ESAI will alter cost per pregnancy. Producers can use a partial budget (Table 5-6) for enterprise analysis of ESAI. Implementation of ESAI can increase returns by increasing the weaning weight of the calves (both age and genetic effects), altering market price by increasing the uniformity of the calf crop, and improving cow productivity by enhancing the number of high-quality replacement heifers. Alternatively, ESAI can reduce potential income because fewer bulls are available to sell as cull bulls. Estrus synchronization and AI increases costs because of costs for synchronization products and supplies, labor, technician, and perhaps facilities. However, ESAI can reduce costs by lowering the number of bulls needed for natural service and reducing the labor hours at calving due to a more concentrated and predictable calving season.

Several factors affect the cost per pregnancy of an estrus synchronization and AI program. Conception rate to the AI influences the cost per pregnancy (Table 5-7). As conception rate to AI increases, the cost of pregnancy of the system decreases. Cost per pregnancy is also influenced by total labor hours associated with the ESAI system, the cost of labor, and the cost of semen. If pregnancy rate is held constant, the cost per pregnancy of ESAI exceeds that of natural service especially for smaller herds. However, if the costs are adjusted for the expected increase in weaning weight of the calves resulting from the ESAI, the cost of pregnancy for Select Synch and MGA-PG is lower to produce a 500-pound equivalent weaned

Table 5-7. Partial budget for synchronization of estrus synchronization plus AI.

Budget Effect	Source	Budget Effect	Source
Increased returns	• Heavier calves (earlier average birth date) • Improved genetics (calves and replacement females) • Uniformity of calf crop (fewer sires could be used, total breeding season could be shorter)	Decreased returns	• Fewer cull bulls to sell
Decreased costs	• Fewer bulls to purchase and maintain • Less labor for more concentrated calving season • More predictable calving ease	Increased costs	• Planning and management for synchronization of estrus and AI • Synchronization products and supplies • Labor • Improved facilities?

Source: Reprinted with permission from Johnson et al., 2003. Kansas State University Cattleman's Field Day 2003. Pub. No. SRP908.

calf (cost per hundredweight of calf). The cost per pregnancy of CO-Synch to produce a 500-pound equivalent calf was only $0.51 per hundredweight higher than that of natural service. If conception rate to AI increases to 60%, the cost per 500-pound equivalent calf is not different between CO-Synch and natural service.

From these data, it seems apparent that the costs of pregnancy are not significantly different between natural service and most ESAI protocols. Of course, if labor is high, if semen costs are excessive, or if conception rate to the AI is low, the cost per pregnancy of ESAI can dramatically increase.

Short-term Return on Investment

Use of ESAI can improve productivity and revenue. Recent research from Dr. Cliff Lamb examined the short-term economic impact of a breeding system that included FTAI + natural service or just natural service in about 1,200 females on 8 different farms (Table 5-8). The breeding seasons began and ended on the same day in both groups on all farms. A partial budget was used to compare the positive economic impact (added revenue, reduced costs) with the negative economic impact (added costs, reduced revenue). Use of ESAI improved short-term returns by about $50. One of the more interesting aspects of this work is that a positive economic impact was observed in 7 of the 8 farms and ranged from +$123 to -$10 per cow. The lone farm that saw reduced revenue did not observe an increase in overall pregnancy rate or a shift in days to calving indicating that the short-term impact (profit/loss) is dictated by the improved reproductive performance normally observed when ESAI is used.

Similar data have collected at UK evaluating the return on investment of incorporating estrus synchronization and AI. Crossbred postpartum cows (n = 351) on one farm were assigned to one of two breeding systems. Approximately two-thirds of the cows (n = 251) were subjected to an estrous synchronization protocol suitable for a fixed-time insemination (SYNC). The remaining cows (n = 100) were exposed to natural service for 60 days (NAT). The bull-to-cow ratio in the NAT treatment was 1:25. The bull-to-cow ratio was different between the SYNC and NAT groups because we anticipated that approximately one-half of the cows in the SYNC group would conceive to AI. To verify date of conception, pregnancy was diagnosed on day 90 using transrectal ultrasonography.

To determine return on investment, all costs associated with the estrus synchronization and AI were recorded and are summarized in Table 5-9. Labor was determined by recording amount of time required to bring the cattle to the corral, work the cows, and then return them to the breeding pastures. Four laborers were used, three trips through the chute, and an hourly wage of $7.00 per hour. To determine differences in revenue, calves were weighed at weaning, and the differences in weight available to market were determined. Calves from both treatments were given a value of $80 per hundredweight.

Table 5-8. Impact of Estrus Synchronization and AI

Treatment	n	Weaning %	Days to Calving	WW (lb) per Cow Exposed	$/Cow
ESAI	582	84	26.8 ± .8	425.5 ± 9.5	+ $49.14
NS	615	78	31.3 ± .8	386.9 ± 9.5	

Source: Rodgers et al., 2012. Journal of Animal Science 90(11): 4055-4062.

Table 5-9. Cost of AI.

Item	Cost per Cow
GnRH	$4.00
Prostaglandin	$4.00
Technician	$5.00
Semen	$10.00
Labor[a]	$2.88
Total	$29.88

[a] 8.6 hours x 3 working days x 4 workers x $7.00 per hour for 251 cows.

Table 5-10. Results of short-term ESAI trial.

	SYNC	NAT	Diff
Cows	251	100	
Calving rate	90%	81%	9%
% calving 1st 30 days	85%	62%	23%
Mean Julian date of calving	74 ± 0.4	84 ± 0.7	10 d
% calf crop weaned	88%	79%	9%
Weaning age	210 ± 9	200 ± 12	10 d
Weaning weight	576.9 ± 18.1	504.8 ± 21.2	72.6 lb
Lb. calf weaned/cow exposed	507.9	398.4	109.5 lb

The results of this trial are shown in Table 5-10. More cows calved in the SYNC group than in the NAT group, and more cows calved in the first 30 days of the calving season in the SYNC versus the NAT treatment. The average date of calving was earlier in the cows in SYNC than in the NAT group. The average weaning weight of calves was heavier from cows in the SYNC than from those in the NAT group. The increase in percent calf crop weaned and weaning weight increased the pounds of calf weaned per cow exposed by nearly 110 pounds.

Return on investment is shown in Table 5-11. Gross revenue increased by $99.62 in the SYNC group. This increased revenue was achieved by investing $29.88 per cow. However, this increase in gross revenue was not achieved without some cost. If the cost of raising the additional calves is included, the net revenue decreases to $73.48. The gross and net gains achieved from this enterprise were $69.74 and $43.60, respectively. The return on investment for the estrus synchronization and AI was 92%, or the producer nearly doubled the money invested. This return does not include savings associated with reduced bull costs. One-half the number of bulls was used per cow in SYNC group than in the NAT group. If savings on bull purchases are included, the gross return increases to $129 per cow, and the return on investment was 432%. These short-term increases in revenue are quite attractive, but the long-term effects of increasing cow productivity by retaining the heifers sired by proven sires are not as easy to determine.

Table 5-11. Increased revenues from ESAI.

	Revenue		
Weaning weight	72.6 lb. x $80 cwt.	=	$58.08
% calf crop	9% more calves x $80 cwt.	=	$41.54
Total revenue		=	$99.62
Return on investment	$99.62 – 29.88	=	$69.74

Table 5-12. Effects of ESAI on production efficiency and profitability in a medium-sized herd.

	Avg. from 1991 to 2000	**2001**	**2002**
No. of females exposed	45	45	44
Calving rate percentage[a]	82%	95%	93%
% calf crop weaned	74.5%	91%	86%
WW Average (lb.)			
Steers	525	542	556
Heifers	484	514	482
Sale Weight[b]			
Steers	554	588	600
Steer sale price (per cwt.)	$77.00	$88.00	$83.00
Lbs of calf weaned per cow exposed	381.2	481.4	448.2
Number of cows sold	5	9	6
Cash cow costs	$235.38	$285.82	$292.26
Net profit per cow exposed[c]	$57.75	$116.62	$76.83

[a] Number of cows calving divided by the number of cows exposed.
[b] Calves were backgrounded for approximately 25 days prior to marketing.
[c] Cash sales per cow minus cow cost.

Long-Term Effects of Estrus Synchronization and AI

Little data are available that address the long-term impact of estrus synchronization and AI in commercial beef cow-calf operations. Two trials were designed to examine the long-term effects of incorporating estrus synchronization and AI into a beef cow-calf operation. The data from the first trial were collected on a single cow-calf operation from 1991 to 2003. Data collected from 1991 to 2000 serve as the baseline or control. During this time period, approximately 45 females (35 to 40 cows and five to eight heifers) were exposed to a 60-day natural service season. Two bulls were used each year. The breeding system used was a two-breed rotational system using Angus and Charolais bulls. The average performance of this herd is illustrated in Table 5-12.

The breeding system was changed to determine the effects of estrus synchronization and AI. All females were subjected to an estrus synchronization protocol suitable for fixed-time insemination (CO-Synch). Females were inseminated to bulls from maternally oriented breeds (Angus and Hereford). Charolais-cross cows were inseminated to the Angus sire, and Angus-cross cows were inseminated to Hereford bulls. Ten days after AI, cows were exposed to a 50-day natural service season. The natural service sire was from a terminally oriented breed (Charolais). Replacement heifers with AI sires were retained. All calves sired by the terminally oriented sire were marketed.

The results from the first two years of the trial are shown in Table 5-12. Incorporation of estrus synchronization and AI increased the percentage of cows that calved, percent calf crop weaned, and the average weaning weight of the steer calves. These increases lead to a marked improvement in pounds of calf weaned per cow exposed. The increases in production efficiency led to increased profitability. Net profit per cow exposed to the bull doubled in the first year and was $20 per cow higher in 2002. Do to unforeseen circumstances, this trial ended in 2002.

Recently, data have been compiled from two farms enrolled in a long-term field study designed to examine the impact of a breeding system on production efficiency. The components of the breeding system included ESAI with natural service (70-day season), organized crossbreeding (Angus, Hereford), and organized selection for the environment (limit purchase feed) and market (post-weaning and bred heifers). One farm was large for the Southeast (150-200 head) while the other was average (23-25 head). At the beginning of the project, average cow size was 1,570 lb. and 1,750 lb. for the large and small farm, respectively. Herd productivity at the start of the project is shown in Table 5-13. An efficient cow weans about 50% of her body weight and these were big cows that were not weaning big calves. We adjusted this by

dividing by the number of cows exposed for breeding to get a new cow efficiency indicator we called percent body weight weaned per cow exposed.

Over the next 7-9 years, cows from these farms were subjected to ESAI followed by a 70-day natural service breeding season. Sires were selected to maximize heterosis in a two-breed rotation and to decrease mature cow size while minimizing possible decrease in weaning performance. Cows were rapidly replaced (15-25% replacement) on both farms with females that were sired by our chosen AI sires.

On both farms, average cow size decreased considerably over time (Figure 5-2). What impact could this have on production efficiency? Smaller cows (1,200 vs. 1,600) simply eat less feed (nearly a ton less; Table 5-13) resulting in lower feed costs per year (Table 5-14).

Reducing cow size normally is associated with a reduction in productivity. In this project, averaging both farms together, the length of the calving season decreased (35 days), pregnancy rate increased (8%), the average age of calf increased (17 days), weaning rate increased (10%), adjusted weaning weight increased (118 lb.), and the pound of calf weaned per cow exposed increased (106 lb.; Figure 5-22).

One of our main goals was to increase cow efficiency. An "efficient operation," as defined above, compares production with costs. If we use cow size as a rough estimate of cost, we can estimate cow efficiency by dividing the percent body weight weaned by the total by the number of cows exposed to breeding. Why are we dividing %BW Weaned by the number of cows exposed? Why not just look at average %BW Weaned? Because the successful cows, those that wean a calf, have to be efficient enough to pay for the cows that fail. Cow efficiency appeared to increase over time. In this project, when we started, the 1,660 lb. cows were weaning about 488 pounds. So, these cows were weaning about 29% of their body weight and about 24% of their body weight per cow exposed to the bull. To date, using this estimate, cow efficiency has increased approximately 10% (Figure 5-23).

Table 5-13. Impact of estrus synchronization and AI.

					Per Cow Exposed	
Farm	No. of Cows	Weaning %	Calving Season	Adj. WW	WW (lb)	% BW
Average	23	93	64 days	521	203	28.9
Large	153	74	123 days	455	337	21.5

Table 5-14. Daily dry matter intake (lb) of beef cows of varying mature weights.[1]

Cow Weight (lb)	Lactation		Pregnancy			Yearly Total	Compared to 1200-lb cow (lb)
	Early	Late	Early	Mid	Late		
1000	24.8		23.5	21.0	21.0	8249	-1095
1200	27.6		26.5	24.1	24.2	9344	0
1400	30.4		29.4	27.0	27.1	10403	1059
1600	33.1		32.2	29.9	30.0	11425	2081

[1] Adapted from NRC (2000).

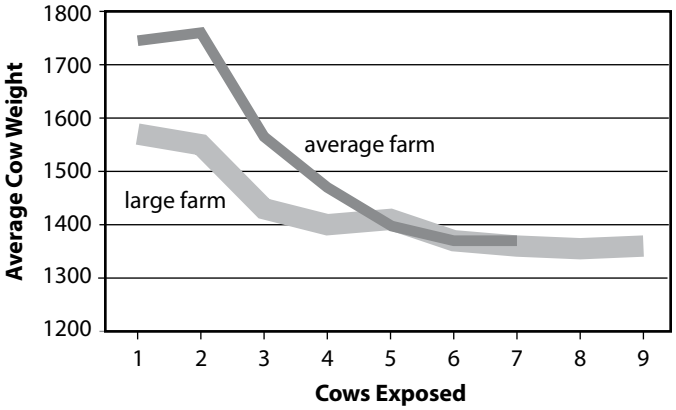


Figure 5-21. Average cow weight (lb).

Conclusions

Estrus synchronization and AI is a profitable enterprise for commercial beef cow-calf operations. The short-term returns on investment were approximately $70 per cow simply by increasing reproductive efficiency and thus the pounds of marketable calf. Additional short-term increases in revenue exist if the producer retains ownership. Data from the Angus Association demonstrated that the carcass value was $206 per head greater

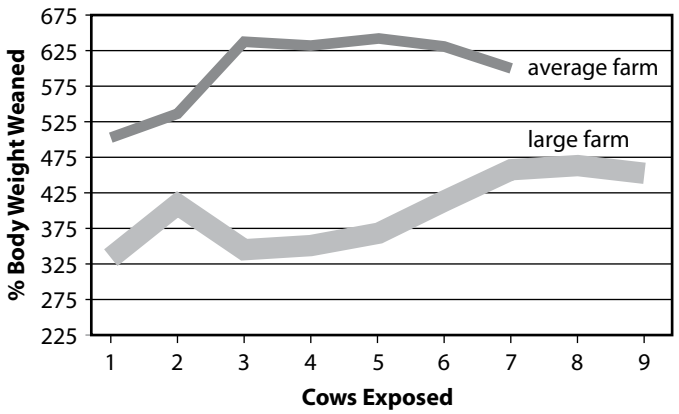


Figure 5-22. Pounds of calf weaned per cow exposed.

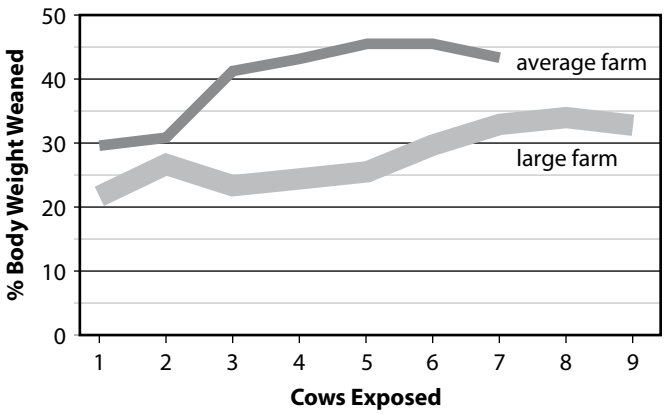


Figure 5-23. Percent body weight weaned per cow exposed.

for sires from the top 10% than the bottom 10% for carcass value. Therefore, if the calves produced from the herds used in the above trials were from sires that were only average and the bulls used for AI were in the top 10% and the cattle were marketed on the grid, an additional $100 to $125 per calf is profited. The key to capturing the greatest potential profit is to utilize alternative marketing systems. However, even in a commodity market, inclusion of ESAI is a profitable rather than costly venture.

Estrus Synchronization Systems for Natural Service

The easiest road to maximum breeding efficiency in the beef cow-calf industry is through estrous synchronization. Estrus synchronization helps shorten the calving season, increases herd pregnancy rates, and helps increase calf uniformity and weight (calves are typically older). Many beef producers also recognize the potential advantage of ESAI. However, many have neither the time nor facilities to utilize estrous synchronization and AI. Systems for use with natural service could markedly improve reproductive efficiency for those producers unable to incorporate AI.

The key to understanding why estrus synchronization improves reproductive rate arises from the fact that all cows do not have the same opportunity to breed. The ability of a cow to conceive during a breeding season is dictated by two main factors; the number of opportunities she has to conceive during a breeding season and her ability to conceive (conception rate).

One method to improve reproductive performance of your cow herd is to synchronize estrus prior to bull turn out. Studies conducted at UK have demonstrated that treatment of cows with a CIDR® device for seven days before natural service can have increase pregnancy rate 5%-10% and can increase the proportion of cows that calve in the first 30 days of the breeding season. Our most recent data indicates that the CIDR® devices only need to be inserted in cows that are likely to have trouble conceiving early in a breeding season; late-calvers and two-year old cows. By "targeting" our reproductive management to these cows, we can improve the whole herd performance and limit our input costs.

Below is just one example of the successful application of this technique. A producer in our IRM Farm Program calves about 150 cows and prefers his herd to calve starting the second week of February. Like many cowherds, the calving season had gotten a bit longer than preferred as several of his cows were calving in late April and May. CIDR® device were inserted into April and May calving cows and all two year olds (25 total cows). The reproductive performance of this group of cows was super. Most (17) conceived in the first 30 days of the breeding season, five conceived in the next 40 days, and three were open. All three of the open cows were two-year olds. One was pretty thin, one calved at the end of April, and the third didn't have an excuse; she just didn't breed back. All the late-calving mature cows conceived. The simple application of the CIDR® device greatly enhanced reproductive performance as nearly 70% of the "problem" cows in this herd conceived early and nearly 95% conceived during the breeding season. This outcome is similar to data from controlled experiments that indicate the tremendous economic impact of synchronizing estrus in cows before natural service.

The length of anestrus impacts the opportunity for a cow to rebreed in a timely fashion. Most cattlemen agree that they would like their cows to calve about every 365 days; if they calve September 1 this year, we would like them to calve about September 1 next year. The length of gestation in beef cattle is about 283 days so cows have on average a cow needs to breed back within 82 days from calving. So, if a cow is anestrus for 65 days

Lastly, ranchers need to develop a plan to enhance the rebreeding potential of their first-calf heifers and late-calving cows. Young cows and late-calving cows have one characteristic in common that will greatly impact their reproductive success; anestrus. After each calving, cows undergo a period of time when they do not come into estrus. This anestrus period can be as short as 14 days but can also last as long as 180 days depending upon a number of factors. Typically, mature cows in good BCS will be anestrus for 45-90 days (avg. about 60-70 days) while first-calf heifers will be anestrous for 75-120 days. Research has shown that only 64% of mature cows have initiated estrous cycles about 70 days after calving while only 50% of first calf heifers have initiated estrous cycles at nearly 90 days after calving. Let's consider the impact of anestrus and calving date for a herd that calves from March 1 until May 10. Bull turnout is May 20th and the length of anestrus for mature cows is 60 days and for young cows is 90 days. A mature cow that calves on March 1 will begin to cycle on May 1 and is highly likely to conceive early. However, the mature cow that calves on April 20 won't cycle until June 20 and her opportunity to conceive early is very limited. A first-calf heifer that calves on April 20 won't begin to cycle until July 20 and will have limited opportunities to conceive. Cattlemen can reduce the anestrous period by fence-line exposure to a mature bull or by treating the cows with progesterone for 7 days prior to bull exposure. Sources of progesterone include the feed additive melengestrol acetate (MGA) or an EAZI-Breed CIDR® insert (Zoetis Animal Health). Both sources have been shown to induce estrus in anestrous cows and exposure of anestrous cows to progesterone for 7 days before bull exposure will not reduce fertility. Pregnancy rates will actually be increased in these females because inducing estrus will increase the number of opportunities these cows have to conceive in the breeding season.

System

A short-term protocol for estrous synchronization and natural service has been developed. This system involves either feeding MGA or inserting a CIDR® device for seven days immediately prior to exposing the females to a bull (Figure 5-24). Data from controlled experiments demonstrate that exposure of females to either MGA or a CIDR® device for seven days before bull exposure can increase pregnancy rate and shift calving distribution dramatically (Table 5-15). These systems to synchronize estrus before natural service improve pregnancy rates by about 9% and increase the percentage of cows that calve in the first 30 days. The normal shift in calving date is about 20 days and results in a 50+-pound increase in calf weaning weights. A CIDR® insert can also be used to induce estrus in cows that have recently calved. Our research

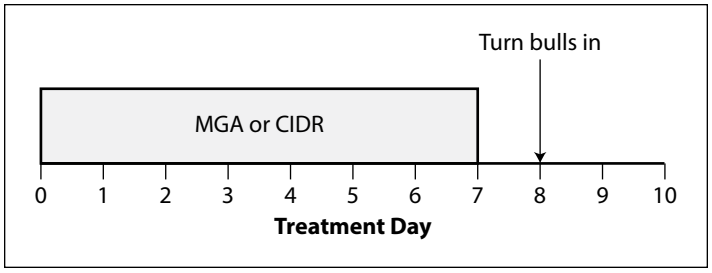


Figure 5-24. Estrus synchronization for natural service.

Table 5-15. Results of synchronizing estrus prior to natural service.

Treatment	Numbers	Preg. Rate	1st 30 d
Control	621	83	47
MGA	614	93	78
Control	419	83	45
CIDR	421	91	80

Bull:cow range from 1:23 to 1:42 (91% PR)

has shown that a CIDR® device can be used to enhance breeding performance in cows as early as 14 days after calving. Here is an example of how to use the CIDR® to improve the reproductive performance of cows that calve late in the calving season. Let's assume that the target calving season is March and April. The plan was to turn bulls out on May 20 but some cows are calving in May. For these May-calving cows, wait 14-21 days after they calve and then insert a CIDR® device for 7 days. Turn the cows into the breeding pasture once the CIDR® is removed. Data on approximately 300 late-calving cows have been collected. Seventy-five percent of mature cows in good body condition treated as described will conceive in the first 30 days of the breeding season and normally cows will calve 30-35 days earlier than the previous year.

Using Sex-Sorted Semen

Progressive cattlemen are constantly working to improving the herd's efficiency and productivity. For those operations that implement artificial insemination already, another potential step to improve production efficiency would be to control the gender ratio of their calf crop. Controlling the gender ratio of a calf crop can be accomplished by incorporating sex-sorted semen into a breeding program. Several scenarios have been outlined below to describe situations where controlling the gender of a calf-crop is desirable.

Semen Sorting Technology

Sorting semen into X- and Y- bearing sperm is possible due to the size differences that exist between chromosomes. Studies indicate that the X-chromosome is about 4% larger than the Y-chromosome. Currently, no other sorting technique is as effective as flow cytometry. Flow cytometry involves 21 steps prior to cryopreservation, compared to three or four steps for conventional semen.

Significant advancements have been made in sperm sorting technology, allowing sex-sorted semen to become commercially available. In the early 1990s, sorting speeds were 200-400 cells/second, sorting accuracy of 83%, and 70% fertility of conventional semen. However, in the last few years, sorting speeds are now 7,000-10,000 cells/second with greater than 90% sorting accuracy, and conception rates near 90% of conventional semen. Typical concentrations of sex-sorted semen have been 2.0 x 10^6, however SexingTechnologies (Navasota, TX) is currently marketing sex-sorted semen at a concentration of 4.0 x 10^6, under the tradename SexedULTRA 4M.

Previous Research

Several studies have indicated reduced conception rates using sex-sorted semen compared to conventional semen of the same sires. Conception rates of sex-sorted semen have ranged from 70-80%, with recent work reporting conception rates near 90% of conventional semen (Figure 5-25). Interestingly, some research has reported favorable conception rates with sex-sorted semen when females expressed estrus prior to insemination. Near normal conception rates had been reported when females expressed estrus prior to insemination. However, when females were non-estrus prior to breeding, conception rates were significantly reduced (Figure 5-26). It is imperative for females to have expressed estrus prior to breeding when using sex-sorted semen to maximize pregnancy potential.

Strategies to Incorporate Sex-Sorted Semen

As mentioned, it is crucial to ensure females have exhibited estrus prior to insemination when breeding with sex-sorted semen. A method to increase conception rates using sex-sorted semen has been to delay insemination in the non-

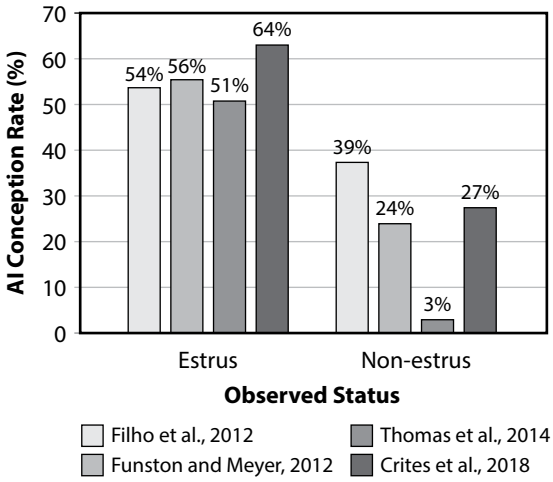


Figure 5-25. Effect of observed estrus status.

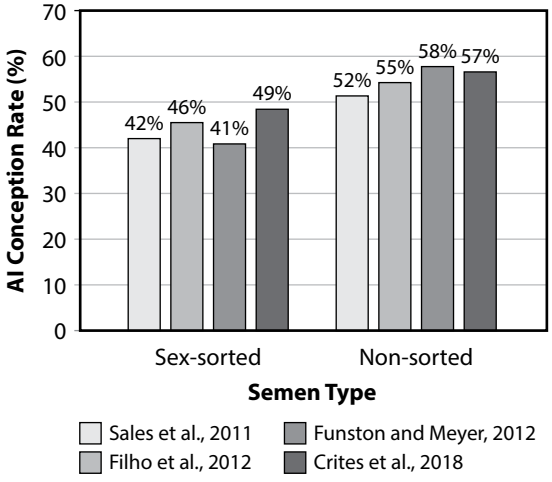


Figure 5-26. Comparison of AI conception rates.

estrus females. In this process known as split-time AI (**STAI**), females that exhibit estrus are inseminated as scheduled and the non-estrus females receive GnRH and breeding is delayed 20 h (Figure 5-27). Several studies conducted in 2014 observed increased conception rates in non-estrus females when using sex-sorted semen in STAI protocols. A concern with STAI is that it requires an additional handling and a second insemination time. This may not be conducive to operations that hire breeding technicians as they would have to schedule two consecutive breeding dates. A 2009 survey of United States beef producers reported labor and time as the two most common reasons that AI was not utilized. Therefore, a protocol that increases both time and labor for producers and professional AI technicians, may limit the adoption of the STAI protocol in commercial beef operations.

Another option when using FTAI protocols, such as the 7-d CO-Synch + CIDR® protocol discussed earlier, would be to inseminate all the females that exhibit estrus prior to the scheduled breeding time using sex-sorted semen and the remaining non-estrual females would be inseminated with conventional semen. This allows for the greatest chance of a successful pregnancy using sex-sorted semen in a single breeding period, as well as increases the pregnancy potential for the non-estrus females.

Can we be more efficient? The goal of most commercial cattlemen is to sell more calves, sell heavier calves, and sell calves that are more valuable. But, can we make our product (calves) more valuable? What would happen to efficiency if we control gender, weaning heifers from our top performing cows and steers from everything else?

For commercial cattlemen, steers simply return more value. Kentucky market data from 2010-2016 (Figure 5-28) demonstrates the value difference in gender. At the same age, steers typically weigh more and are worth $146.71/hd more in revenue. Sex-sorted semen has been available for use for several years and is used most often in the dairy and beef seedstock industries. Conception rate of sex-sorted semen was initially too low for most cattlemen to consider but the sorting/freezing process has improved considerably and conception rates now are basically similar to conventionally-frozen semen. Sex-sorted semen costs slightly more. Male-sorted beef semen normally costs about the same as conventional but female-sorted beef semen is about 50% more ($50 conventional = $75 female sorted). Does the additional value of gender control pay for the added costs? In a typical 30-cow herd, 13 steers and 13 heifers might be weaned (88% weaning rate). Using the values from the above dataset, the steers would be worth $12,035 while the heifers would be worth $10,128. Let's assume that we implement an ESAI system suitable for fixed-time AI using sex-sorted semen and conception rate to AI is 50%. We breed 6 cows to female-sorted semen and 24 to male-sorted semen. We can either use natural service to clean up or shift to a total AI system. Both systems are shown in Table 5-17.

Table 5-16. Results of synchronizing estrus prior to natural service.

Treatment	Numbers	Pregnancy Rate (%)	Percentage Calved in 1st 30 days (%)
Control	621	83	47
MGA	614	93	78
Control	419	83	45
CIDR	421	91	80

Bull:Cow range from 1:23 to 1:42 (91% pregnancy rate).

At first glance, the data in Table 5-16 is not impressive. Remember, this is just the added revenue resulting from the shift in gender ratio. Shifting from natural service to an ESAI system has been shown to increase short-term revenue by about $50 per head. Shifting gender ADDS $24-37 more revenue per head making the shift to ESAI even more attractive. This value is underestimated slightly because market value will be about $2 higher per hundred in both of the groups subjected to ESAI due to marketing 14 versus 19-22 "like" steers in a group. Revenue can be even higher if the producer selects carcass-oriented genetics, ownership is retained, and the steers are fed to hit a high-value grid. Using sex-sorted semen will increase costs slightly; in the above example, six females will be inseminated using female-sorted semen that will only increase the total cost about 10%. Long-term, using maternally-oriented genetics on your top cows should increase maternal performance.

The road to efficiency travels through ESAI. Compared to typical natural service, use of ESAI increases revenue, optimizes heterosis, and matching geno-

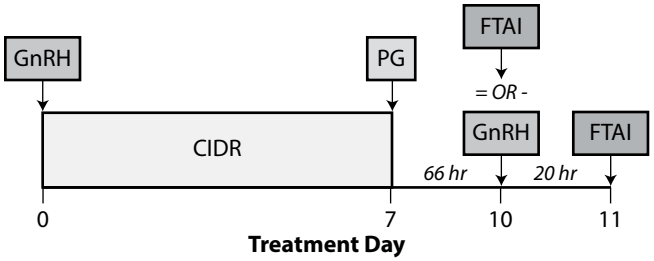
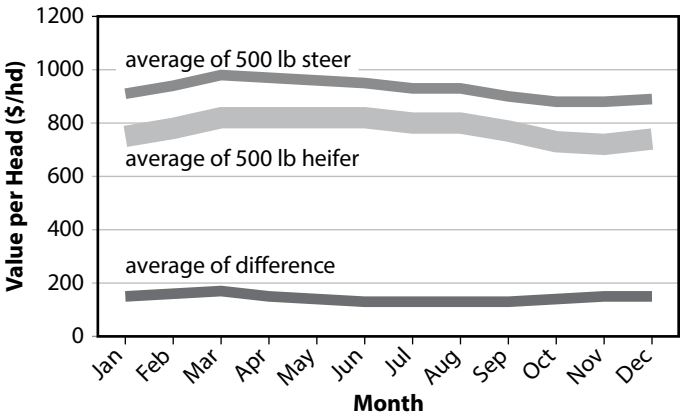


Figure 5-27. Split-time AI.



USDA-AMS Kentucky Weekly Livestock Summary, 2010-2016

Figure 5-28. Average steer and heifer value, 2010-2016 status.

type with market and environment. Long-term, producers can make real strides in cow efficiency and improve their opportunities for profit. Controlling gender offers exciting opportunities for all cattlemen to take their operations to the highest possible level.

Table 5-17. Characteristics of the bovine fetus during pregnancy.

Day of Gestation	Approx. Size	Inches	Characteristics
30 (1 mo.)	1/100 oz.	½	Some fluid in embryonic vesicle (marble size)
45 days	1/8 oz.	1	Gravid horn enlarged
60 (2 mo.)	1/4 oz.	2	Fetus size of a mouse, uterine horn banana size (2 in. diameter)
90 (3 mo.)	8 oz.	6	Fetus size of a small rat, uterine horns 3 in. in diameter and dropping into abdominal cavity
120 (4 mo.)	2 lb.	12	Fetus size of a small cat, uterine horns 5 in. in diameter, placentomas are palpable
150 (5 mo.)	5 lb.	18	Fetus size of a cat, might be too deep in abdominal cavity to palpate, uterine horns 7 in. in diameter, placentomas 2 to 2.5 in.
180 (6 mo.)	11 lb.	24	Fetus size of a small dog
210 (7 mo.)	23 lb.	30	Fetus is easily palpated from this point till term
240 (8 mo.)	47 lb.	36	Fetus is easily palpated from this point till term

283 (term): Size depends on genetic and environmental factors.

Potential Reasons to Utilize Female-Sorted Semen

Producers looking to expand the size of their operations could do so rapidly by increasing the number of female calves born. This eliminates the need to purchase any replacement females and reduces the risk of bringing in any outside diseases. Both seedstock and commercial cattleman could have a potential market for selling yearling heifers and bred females to other producers. One thought is to breed all yearling heifers with female-sorted semen. Research has demonstrated that heifer calves usually come smaller at birth and it has also been found that breeding a heifer to have a smaller calf reduces the incidence of dystocia.

It may be the case that certain sires produce females that make extremely good cows (i.e. phenotypically, high fertility, performance) that perform well in a particular environment. Additionally, it might also be that a heifer calf is more desirable from a certain cow family. Perhaps these females are genetically superior, good structured, sound on their feet and legs, display high udder quality, wean heavier calves, exhibit increased fertility, better fit the environment, and ultimately make superior dams as a mature cow. Using female-sorted semen allows producers to select the matings that they would like to generate daughters from.

Potential Reasons to Utilize Male-Sorted Semen

A seedstock producer's main goal is to generate and sell bulls for commercial cow-calf operations and to other seedstock breeders as well. Selecting and using sons from proven, high-accuracy sires can make rapid improvements in the genetic progress of herds. Additionally, by using male-sorted semen, bulls can be produced from the best dams for different marketing scenarios.

In commercial beef production, not only is a feeder steer typically worth more money per pound, but male calves also gain more from calving to weaning then female calves on average. Data from feeder calf sales from 2010 to 2016 in Kentucky indicated that the average value of a 550 lb. steer was $925.76/hd and a 500 lb. heifer was $779.05/hd. Using these values, a steer is worth $146.71 per head more than their heifer contemporaries. This price difference highlights why it would be desirable for commercial producers to maximize the number of steer calves marketed.

Incorporating Both Genders

A proposed method to utilize sex sorted semen of both genders in a crossbreeding system known as Two-Breed Rotational and Terminal-Sire, that was previously described by Gregory and Cundiff (1980). This breeding system involves breeding all replacement females and 25% of the mature cows to female-selected semen of maternal sires. The remaining cows in the herd would then be inseminated with male-selected semen using a terminal sire. This breeding scenario would capture the maximum advantage of breed differences for maternal and terminal roles and the maximum advantage of individual and maternal heterosis.

Scenario Summaries

These scenarios describe several potential avenues for incorporating sex-sorted semen into breeding programs for both commercial and seedstock cattlemen. Before incorporating sex-sorted semen into a breeding program an economic analysis should be conducted; as each farm and ranch operation experiences different input costs and marketing opportunities. While sex-sorted semen may not be appropriate for every operation, it has the potential to increase the production efficiency in the cattle industry.

Pregnancy Testing

Pregnancy diagnosis is a management tool used to identify nonpregnant females and to aid in grouping pregnant females according to anticipated calving dates.

Pregnancy testing offers the following advantages:

- Pregnancy diagnosis provides early warning of breeding problems, such as infertility in males and problem breeders in females.
- Management decisions can be made regarding rebreeding or sale of nonpregnant females.
- Separation and grouping of females based on pregnancy status improves feed utilization and enhances management efficiency.
- Improved utilization of facilities is possible.
- It is possible to guarantee pregnancy in females available for sale.
- Most importantly, producers can avoid the additional expenditures associated with feeding cows that fail to produce a calf.

Pregnancy diagnosis in cattle is generally performed by rectal palpation. A thorough understanding of the female reproductive system is essential in order to accurately perform a pregnancy examination. Realtime ultrasonography is used routinely to diagnose pregnancy and

determine fetal sex. Table 5-22 provides a summary of fetal development and identifying characteristics based on fetal age.

Practice and experience are the keys to accurate palpation. In most instances, the producer should not be the one to palpate but should supervise the operation and critically observe cows as they are processed through the chute. This provides an ideal time to begin making decisions regarding which cows to keep and which to cull.

Pregnancy diagnosis should be performed at the stage of gestation that the technician feels most comfortable with. Some technicians are more comfortable and more accurate at earlier stages of gestation (i.e., less than 120 days), while others are more comfortable at later stages (i.e., greater than 120 days). In general, cows should be diagnosed for pregnancy at some point in the fall so that culling decisions can be made before winter feeding.

The easiest and most accurate method of pregnancy diagnosis is blood sampling. Several laboratories in Kentucky can analyze blood samples for the presence of Bovine Pregnancy Specific Protein, a protein that is only produced by the placenta. Pregnancy can be diagnosed in females as early as 26 days of pregnancy and the total costs per cows is approximately $5. The accuracy of the test is greater than 95 percent. Here is a link to a YouTube video demonstrating how to take a blood sample for determining pregnancy. https://www.youtube.com/watch?v=IuNbsTMrIuI&t=9s

Reproductive Biotechnologies

Reproductive biotechnologies include estrous synchronization, artificial insemination, superovulation, embryo recovery and transfer, cryopreservation of sperm and embryos, sexing semen, *in vitro* fertilization, bisection and cloning of embryos, biopsy of embryos for sex determination and other genetic analyses, and transgenic technology.

This list can be expanded to include even more procedures; however, it is generally assumed that, at least at this point, selective breeding programs are perhaps more profitable for the majority of beef cattle operations than the biotechnologies listed. Estrus synchronization and artificial insemination are the most important and widely applicable technologies currently available and, at present, offer the best opportunity to affordably impact a beef production system.

Heifer Development Strategies to Improve Reproductive Efficiency

Improvements in reproductive efficiency certainly impact profitability in beef cow herds. The first step in improving reproductive efficiency is to properly manage reproduction in yearling heifers. Research has clearly demonstrated that heifers that conceive earliest in their first breeding season become more productive and more profitable cows. The goal of a heifer reproductive management program should be to give heifers the opportunity to conceive early and to reduce calving difficulties. So the goal is to identify management practices that increase the opportunity for yearling heifers to conceive early and calve without trouble. The key to proper heifer development lies in understanding the factors that influence successful heifer development. The key factor regulating heifer development is age at puberty. Most producers do not consider age at puberty of their heifers to be a major problem, yet few know how many heifers are actually cyclic at the beginning of the breeding season. A Nebraska study demonstrated that the proportion of heifers that were pubertal on the first day of the breeding season varied greatly over five consecutive years in a single a herd. The percentage of heifers that were pubertal on the first day of the breeding season ranged from 21% to only 64% over the five-year period. For maximum fertility and reproductive performance, heifers must have had at least one estrus *before* the beginning of the breeding season. The goal then is to incorporate reproductive management tools to reduce the age of puberty, increase fertility, and shorten the interval to conception.

The three main factors that regulate the onset of puberty are age, weight, and genetic makeup of the heifer. Age most limits the onset of puberty. Heifers must reach a minimum biological age before the pubertal process can be initiated. The second factor that regulates puberty in the heifer is weight. For puberty to occur, heifers must weigh at least 65 to 70% of their mature weight. This weight is referred to as their target weight. More information on heifer development rations can be found in Chapter 8, Feeding the Beef Herd. Most heifer development programs require that heifers reach their target weight, approximately 67% of their expected mature weight, by the onset of their first breeding season. Because fertility increases until the third estrus after puberty, heifers should reach their target weight at least 30 days before the start of the breeding season. The final factor regulating puberty is genetic makeup of the heifer. Age at puberty has a highly negative correlation with milk production. In other words, breeds that excel in milk production reach puberty at a younger age than lower milking breeds. Within the British breeds, the heavier milking breeds, Angus and Shorthorn, reach puberty at a younger age than the lighter milking breed, Hereford. Within the Continental breeds, Simmental and Gelb.vieh reach puberty at a younger age than Charolais, Limousin, and Chianina. Age at puberty is an even greater problem in breeds with Brahman influence. Females from Brahman-influenced breeds can reach puberty as late as 24 months of age.

The only breeding management tool available for reducing the age at puberty is crossbreeding. Lowly heritable traits, such as reproduction, are greatly enhanced by heterosis (see Chapter 6: Planning the Genetics Program).

Successfully Managing Heifers

How are heifers successfully managed to reach puberty at an optimal time? Proper heifer development begins at weaning. At weaning, select the oldest heifers that are heaviest with respect to their target weight. Remember, age and weight are two key factors that determine age at puberty. Also, select at least 20% more heifers for development than are needed for replacements. Developing additional heifers allows the producer to cull heifers that do not perform during the development.

The next step is to set the breeding date. It is widely recommended that heifers be bred 20 to 30 days before the mature cowherd. For example, if the mature cows start calving on March 1, the heifers should start calving approximately February 1. Use a gestation table to determine

the start of the breeding season. In this example, the breeding season starts on April 25. To ensure that only the most fertile heifers are selected for replacements, limit the breeding season to only 30 days and cull those heifers that do not conceive. After the start of the breeding season is determined, determine the number of days from weaning to breeding, then subtract 30 days. Research has clearly demonstrated that fertility increases approximately 20% from the first to the third estrus. Therefore, it is logical to manage heifers to reach puberty before the breeding season begins. If the heifers were weaned on October 1, there are 207 days from weaning until the breeding season starts on April 25. Subtracting 30 days leaves 177 days for the heifers to reach their target weight.

Next examine the cowherd and determine the approximate weight of the cows. Use this weight to set the target weight of the heifers. The target weight is 67% of their expected mature weight. Then determine the amount of weight gain needed to reach the target weight. If the average mature weight of the cowherd is 1,200 pounds, the target weight of the heifers is 800 pounds. If the heifers weighed on average 500 pounds at weaning, the heifers need to gain 300 pounds to reach their target weight. Dividing the weight by the number of days indicates that the heifers need to gain approximately 1.7 pounds per day to reach their target weight 30 days before the start of the breeding season. Once the weight gain is determined, a ration should be developed so those heifers can reach their target weight. It is a good practice to weigh the heifers periodically to ensure that they are gaining the appropriate amount of weight. If they are not, the ration can be adjusted to compensate for any discrepancies.

The next important phase in heifer development occurs one month prior to the start of the breeding season. At this time, pelvic area measurements and reproductive tract scores should be determined for each heifer. Pelvic area is a measurement of the size of the birth canal in heifers. Heifers with small pelvic areas and especially large heifers with small pelvic areas tend to have greater difficulty calving. The key question then becomes what size pelvic area is too small? Gene Deutscher and co-workers at the University of Nebraska developed tables to help producers to relate size of heifer, size of pelvic area, and the potential size of an easily deliverable calf (tables 5-18 and 5-19). To determine the size of a deliverable calf (Table 5-18), divide the pelvic area by the appropriate ratio as determined by age and weight. For example, an 800-pound yearling heifer with a pelvic area of 180 square centimeters should be able to deliver a 78-pound calf (180/2.3) with little difficulty. Most heifer development professionals cull those heifers with a pelvic area that is inadequate to allow delivery of a 70- to 75-pound calf. In other words, an 800-pound heifer with a pelvic area less than 160 square centimeters should be culled. It is important to recognize two facts. One, the ratios used to determine size of a deliverable calf are only about 80% accurate, so some variability does exist in this model. Second, producers should set their own pelvic area minimum that fits within their individual production situation. In other words, if you want your 800-pound yearling heifers to be able to deliver an 80-pound calf, set your pelvic area limit at 184 square centimeters.

Heifers should also be subjected to a reproductive tract score. Reproductive tract score is used to determine the maturity of a heifer. Reproductive tract scores (RTS) range from 1 to 5, and heifers with higher reproductive tract scores are more mature. If estrus synchronization is *not* going to be used, cull those heifers with a RTS less than 3. If estrus is to be synchronized using melengestrol acetate (MGA), an RTS of 2 is acceptable.

At this time heifers should also be vaccinated against Vibrio fetus, Leptospirosis, and the respiratory disease complex, which includes PI_3, BRSV, BVD, and IBR. A modified-live vaccine is preferred because this vaccine generally stimulates a better immune response. Heifers also need to be dewormed at this working.

The final step in heifer development is breeding. Producers should consider estrus synchronization and/or AI. There are many advantages to estrus synchronization and AI. The advantages of estrus synchronization include higher pregnancy rates; heavier, more uniform calves at weaning; and increased production and labor efficiency. The greatest advantage of AI is the ability to use superior, more predictable sires. Since a majority of calving problems in a herd occur when calving first-calf heifers, it seems only logical to use estrus synchronization and AI to proven calving-ease bulls.

Proper heifer development is one of the key components to profitability in a beef cattle operation. Understanding the principles of heifer development can enable producers to incorporate management techniques to improve the efficiency of the operation.

Table 5-18. Using pelvic measurements to estimate deliverable calf size (birth weight).

Time of Measurement	Heifer Age (mo.)	Heifer Wt. (lb.)	Pelvic Area ($cm.^2$)	Pelvic Area/Birth Wt. Ratio	Estimated Calf Birth Wt. (lb.)
Before breeding	12-13	600	140	2.1	67
			160	2.1	76
			180	2.1	86
Pregnancy exam	18-19	800	180	2.7	67
			200	2.7	74
			220	2.7	82

Source: Deutscher, 1988. Journal of Animal Science 66(5):1081-1088.

Table 5-19. Pelvic area/calf birth weight ratios for various heifer weights and ages to estimate deliverable calf birth weight.

Heifer Wt. (lb)	Age at Time of Measurement (mo.)			
	8-9	12-13	18-19	22-23
500	1.7	2.0	--	--
600	1.8	2.1	--	--
700	1.9	2.2	2.6	--
800	--	2.3	2.7	3.1
900	--	2.4	2.8	3.2
1000	--	2.5	2.9	3.3
1100	--	--	--	3.4

Source: Deutscher, 1988. Journal of Animal Science 66(5):1081-1088.

Diversity among Breeds

Table 5-20 groups breed crosses by their biological types and four other criteria. The table summarizes data from the Meat Animal Research Center for 19 F1 crosses grouped into seven biological types based on relative differences (X lowest, XXXXXX highest) in growth rate and mature size, lean-to-fat ratio, age at puberty, and milk production. These data show that faster-gaining breed groups of larger mature size reach puberty at later ages than do slower-gaining breed groups of smaller mature size. Breeds that have a history of selection for milk production (e.g., Gelb. Vieh, Brown Swiss, and Simmental) tend to weigh less at puberty than do those with the same genetic potential for growth and mature size that are not selected for milk production (e.g., Charolais, Limousin, and Chianina).

Heifers sired by breeds with a large mature size tend to be older and heavier at puberty than heifers sired by breeds with a smaller mature size. The relationship between mature size and age at puberty can be offset by associations with milk production (i.e., heavier milking breeds or lines within a breed reach puberty at younger ages and lighter weights). When these interpretations are expanded to mature cows, it is evident that the additional nutrient requirements of cows of large size and higher milk production potential must be met, or the intervals from calving to first estrus increase and conception rates decline.

Matching the Development Program with Genotype

Most components of fertility that influence first calving and subsequent reproductive performance are not highly heritable. This suggests that management practices are most likely to influence the majority of factors related to reproductive performance. How replacement heifer calves are managed from the time they are weaned from their dams to the beginning of the first breeding period is critical for their subsequent performance.

Studies indicate that puberty can be expected to occur at a genetically predetermined size among individual animals, and only when heifers reach target weights can high pregnancy rates be obtained. In other words, heifers with the genetic potential to reach a heavier mature weight must attain a heavier prebreeding weight before their first breeding season. Using the standard set by the Beef Improvement Federation for nine frame-size classifications for U.S. breeding cattle (Table 5-21), producers can estimate body composition and energy requirements per pound of gain at various weights during the feeding period.

Optimal growth rates for replacement females of various body types are also available. These growth rates (Table 5-22) represent optimums for heifers that vary in mature size; they were established to maximize female lifetime productivity. The target weight principle calls for feeding heifers to a prebreeding target weight that represents 67% of the heifer's projected mature weight.

Table 5-20. Breed crosses grouped in biological type on the basis of four major criteria.[1]

Breed Group	Growth Rate & Mature Size	Lean:Fat Ratio	Age at Puberty	Milk Production
Jersey	X	X	X	XXXXX
Hereford-Angus	XX	XX	XXX	XX
Red Poll	XX	XX	XX	XXX
Devon	XX	XX	XXX	XX
South Devon	XXX	XXX	XX	XXX
Tarentaise	XXX	XXX	XX	XXX
Pinzgauer	XXX	XXX	XX	XXX
Brangus	XXX	XX	XXXX	XX
Santa Gertrudis	XXX	XX	XXXX	XX
Sahiwal	XX	XXX	XXXXX	XXX
Brahman	XXXX	XXX	XXXXX	XXX
Brown Swiss	XXXX	XXXX	XX	XXXX
Gelbvieh	XXXX	XXXX	XX	XXXX
Holstein	XXXX	XXX	XX	XXXXXX
Simmental	XXXXX	XXXX	XXX	XXXX
Maine-Anjou	XXXXX	XXXX	XXX	XXX
Limousin	XXX	XXXXX	XXXX	X
Charolais	XXXXX	XXXXX	XXXX	X
Chianina	XXXXX	XXXXX	XXXX	X

[1] X lowest, XXXXXX highest.
Source: Cundiff, 1986. Crosssbreeding Beef for Western Range Environments. University of Nevada-Reno and USDA TB-88-1.

Table 5-21. Body weight and height of breeding females of different frame sizes.[1]

Frame Score	205 Day		426 Day		Maturity	
	Height	Weight	Height	Weight	Height	Weight
1	35	356	41	580	44	880
2	37	375	43	618	46	953
3	39	396	45	653	48	1,027
4	41	418	47	693	50	1,100
5	43	438	49	728	52	1,172
6	45	458	51	766	54	1,247
7	47	480	53	803	56	1,320
8	49	499	55	838	58	1,393
9	51	521	57	880	60	1,467

[1] Hip height (in.) based on Beef Improvement Federation standards. Weights (lb.) are expected averages for flesh condition (body condition score 5; Fox et al., 1988).

Table 5-22. Optimum growth rate for breeding herd replacement females.[1]

	Frame Size				
	1	3	5	7	9
Optimum weight at first estrus, lb.	580	653	728	803	880
Mature weight, lb.	880	1,027	1,172	1,320	1,467

[1] Optimum weight or target weights at which reproductive cycles are initiated are reinitiated as soon as possible without excess fat deposition that will inhibit milk production and reproduction (Fox et al., 1988).

Management of Heifers at Calving

At least two weeks prior to calving, move heifers to an accessible area. An ideal situation would be a small pasture near a corral, complete with a place to deliver calves and a small pen for getting heifers to "pair up" with their calves after they are born. Check heifers at least three times a day during the calving season.

Keep heifers separated from the older cows, and supplement them to meet their nutrient needs after calving. Heifers nursing their first calves often have low conception rates or are slow to rebreed. Inadequate nutrition is often at fault. Rations should contain ample energy. Many producers turn heifers on to spring grass after they calve. Most immature grasses are of high quality. However, cattle must consume large quantities of grass, due to its high moisture content, to meet their nutritional needs. Supplementation with high-energy feeds, such as grain or soyhulls, is justified when grass is short or sparse.

Producers should emphasize high fertility, early pregnancy, and ease of calving when managing heifers. These are more important than trying to get calves with heavy weaning weights from first-calf heifers.

Management during Calving

Death of calves at or near calving time represents a major economic loss for beef producers. A newborn calf represents the chance to recover the annual cost of maintaining the beef cow and obtain a profit. Death rates in excess of 5% unfortunately are not uncommon at calving time. You generally can prevent these losses by providing keen management to the beef herd during the calving season. It is important to have a short calving period so you can provide frequent observation and assistance if needed.

Here are some specific things you can do:

- Separate first-calf heifers from mature cows. Calving difficulty can run as high as 30 to 40% for two-year-old heifers, whereas 3% might be normal for mature cows. It is especially important to closely observe first-calf heifers. Place them in a small, accessible pasture near a corral where assistance can be given if needed.
- Provide a clean area for calving. The calving area should be a well-sodded pasture or clean, dry maternity pen instead of a wet, muddy lot. Calving pastures should be large enough to permit adequate exercise and offer protection against prevailing winds.
- Be familiar with the signs of calving. The earliest sign that may be noticed is enlargement of the udder; however, this can occur several weeks before calving. Several days before calving, the ligaments around the tailhead and in the pelvic area relax. The vulva becomes swollen and may begin to sag with strings of mucus appearing. Within a few hours of calving, most cows become nervous and uneasy. Cows generally wander away from the rest of the herd as contractions increase.
- Check cows frequently. Close observation is needed so that assistance can be given to cows with calving difficulty. Observing cows three or four times daily and providing assistance as needed results in more live calves. However, cows should be disturbed as little as possible during labor.
- Know when cows need assistance. Intervention is justified when two or three hours have passed without progress or if delivery has not occurred within 90 minutes after the water sac appears. In a normal delivery, the calf's forelegs and head, surrounded by membranes, are forced through the birth canal and appear from the vulva. Train yourself to recognize an abnormal delivery, and know when professional help is needed. Using a disposable glove, determine the position of the calf by feeling the parts of the calf.
- If a cow/heifer needs assistance, wash around the vulva with soap and water, and dry with paper towels.

When the calf is in a normal position, the bottoms of the feet are face downward and the head can be felt between the front legs. Some abnormalities—such as one or both forelegs back or head turned back—can be corrected by pushing the calf back and putting the extremities into the correct position. Figure 5-29 illustrates some normal and abnormal presentations of the calf at parturition.

The cow needs help when these conditions occur:

- Presentation is backward (dew claws are facing upward).
- Only the calf's head or tail is visible.
- The front feet protrude past the knees, but the calf's nose cannot be located.
- The head and one foot are visible.
- More than two feet are visible.

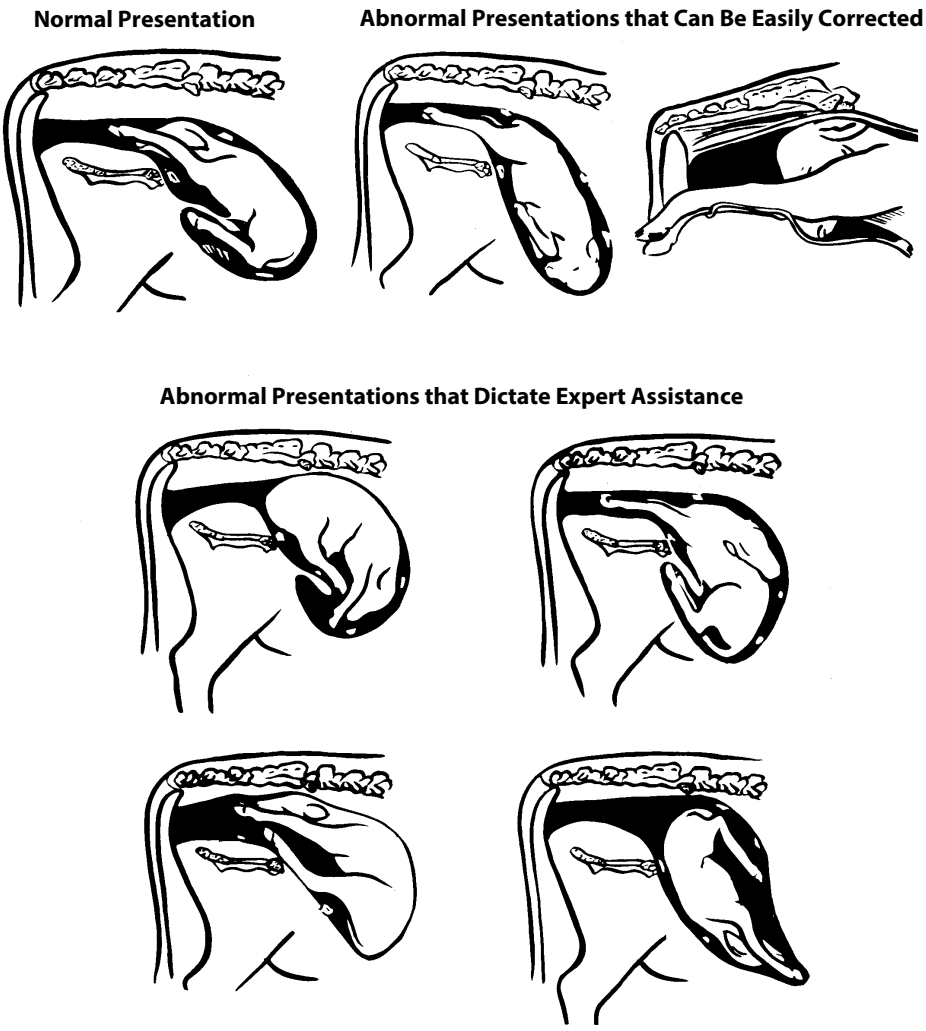
What to Watch

- Be sure the calf is breathing normally. After the calf is delivered, some stimulation may be required to start its breathing. You can rub it briskly, slap it on the ribs, or tickle its nostrils with a piece of straw. Remove mucus from the mouth and throat. Lifting the calf up by the hind legs helps drain fluids from the respiratory system.
- Be sure the calf consumes colostrum. Every calf should ideally consume colostrum (first milk) within 15 to 30 minutes after birth. A newborn calf depends on colostrum as a source of antibodies to protect it from diseases. The sooner a calf receives colostrum, the better its protection will be. Saving and freezing colostrum or using a commercial colostrum supplement helps save calves that do not nurse within one to two hours after birth. Give colostrum through an esophageal feeder to calves that were assisted during calving. Use a lubricant (petroleum jelly, etc.) on the ball of an esophageal feeder.
- Increase feed after calving. Increase the cow's energy intake to about 16 pounds of total digestible nutrients (TDN) per day as soon as the calf appears to be taking all of the milk (10 to 14 days after calving). The extra energy helps the cow produce enough milk for her calf and rebreed on schedule.

For more detailed information regarding calving cows, please refer to Chapter 7: Health and Management Techniques.

Proper Management of Young Cows

The single greatest source of reproductive inefficiency is the rebreeding of young cows (those two to three years old). The reduced fertility of young cows is the result of a greatly extended postpartum interval. The postpartum interval (i.e., the time period from calving to the initiation



Source: *Hardin, R. 1986. Factors Affecting Calving Difficulty. Athens, GA: University of Georgia Cooperative Extension Service. Bulletin 943.*

Figure 5-29. Normal and some abnormal presentations of the calf at parturition.

of estrous cycles) is primarily regulated by the following four factors:

- Suckling and the maternal bond
- Time
- Nutrition
- Calving difficulty

Suckling and the Maternal Bond

The single greatest factor controlling anestrous in beef cows is suckling of the calf and the presence of the maternal bond. The influence of suckling is illustrated in Table 5-23. If a calf is weaned at birth, the female initiates estrous cycles 14 days later. The postpartum interval increases as the number of times a calf is nursed daily. A considerable amount of research has demonstrated that estrus can be induced in most (about 80%) anestrous females by removing the calves from the cows for 48 hours. This short-term removal was not found to influence either the incidence of illness or the weaning weight of the calves. Producers could utilize short-term weaning by removing the calves from all young cows, thin cows, and late-calving cows the first two days of the breeding season. Calves should have access to hay and water. Short-term weaning can also be used in estrus synchronization and AI protocols. If using CO-Synch, remove the calves from the cows the day the PG is given and return after breeding. Research from Colorado State University has demonstrated that combining short-term calf removal with CO-Synch will improve pregnancy rates 12% compared to CO-Synch alone.

Table 5-23. Influence of suckling intensity.

	Continuous Nursing	Milked 4x/day	Nursed 1x/day	Weaned at Birth
Interval to first heat (days)	62	44	35	14

Time

Because of the nutrient requirements for growth, young cows simply need more time after calving to attain adequate available energy to initiate estrous cycles. Research has clearly demonstrated that most cows do not stop growing until they are four years of age. Interestingly, this is when cows enter their most productive years. The postpartum interval is 20 to 30 days longer for young cows. One method to overcome this problem is to breed yearling heifers to calve 20 to 30 days before the mature cowherd.

Breeding heifers to calve early has two distinct advantages. First, calving heifers earlier greatly increases the proportion of young cows that are cyclic on the first day of the breeding season and increases the pregnancy rate of these cows. Second, calving heifers before the cowherd enables closer examination of heifers at calving and could decrease calf death loss due to calving problems. On the other hand, calving heifers early also has two disadvantages. First, early calving lengthens the overall calving season. Second, choosing an appropriate time for early calving can be difficult. For example, if a producer calves the mature cowherd in February and March, does this producer want to calve the heifers in January? Perhaps the best solution is to calve heifers two weeks before the mature cowherd. Calving two weeks early will increase cyclicity and pregnancy rates without extending the calving season significantly.

Nutrition

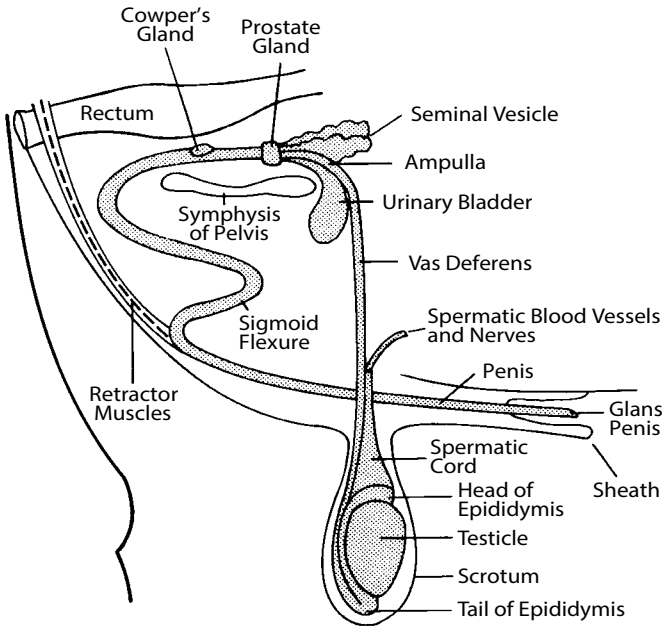
The influence of nutrition and body condition score (BCS) on reproductive efficiency is discussed in Chapter 8: Feeding the Beef Herd. Generally, maintaining cows at a BCS of 5 from calving to rebreeding is recommended. However, some recent data from Oklahoma State University (Table 5-24) suggest that perhaps more condition is necessary to maximize reproduction when calving two-year-old cows. In this experiment,

pregnancy rate was examined in 450 two-year-old cows that calved with a BCS from 4 to 7 (Table 5-25). Data from this experiment clearly demonstrate that reproductive efficiency is higher in two-year-old cows that calved with a BCS of 6 compared to a BCS of either 4 or 5. No difference in either calf birth weight or calving difficulties was reported. Increasing the BCS of two-year-olds seems warranted.

Type of supplement fed may also influence reproductive efficiency. An experiment from the USDA Research Center in Miles City, Montana, examined the effects of feeding high-fat supplements on rebreeding performance in two-year-old cows. In this experiment, 149 two-year-old cows were supplemented with either a corn-soybean meal (CSM) mixture or with a whole oilseed. Supplementation occurred over the last 60 days of pregnancy. The three oilseeds tested were soybeans, safflower seeds, and sunflower seeds. Each supplement contained equal levels of energy and protein. No difference was observed between treatments in dam BCS, dam weight, calving ease, birth weight, or the proportion of cows that were cyclic on the first day of the breeding season. However, more cows became pregnant and calf weaning weight was higher in cows fed whole oilseeds compared to those fed CSM. Similar results have been observed in experiments at the University of Kentucky and at the University of Missouri. Combining the results, feeding young cows 3.5 to 5 pounds each of whole soybeans either during late pregnancy or from calving to the middle of breeding season has the potential to increase pregnancy rate and reproductive performance.

Calving Difficulty

Calving difficulty extends the period of anestrous. Females that experience calving difficulty are 16% less likely to conceive than those that do not. Cows that have a prolonged labor (i.e., more than four hours), even though they calve unassisted, have longer periods of anestrus. Cows that receive assistance early return to estrus more quickly and have a high pregnancy rate. The best method of reducing calving difficulties is by using proven, calving-ease sires and by using pelvic area measurements as a culling tool, which was discussed earlier.



Source: *Turman and Rich. 1977. Reproductive Tract Anatomy and Physiology of the Bull. Great Plains Beef Cattle Handbook GPE-8450. Cooperative Extension Service, Great Plains States.*

Figure 5-30. Diagram of the reproductive system of the bull.

Table 5-24. Effect of calving difficulty on reproductive performance of 2-yr.-old heifers calving first calves.

	Postpartum Anestrus (days)	Cyclic at Beginning of Breeding	Services per Conception	Preg. Rate
Short labor	61	87	1.16	88
Long labor	64	70	1.30	69

Table 5-25. BCS and reproductive performance of young cows.

BCS	Preg. n	Rate %	Days to n	Preg. Days
4	73	65	47	92
5	157	71	100	82
6	120	87	96	74
7	73	91	61	76

Reproduction in the Bull

Figure 5-30 shows the reproductive tract of the bull. The bull's organs of reproduction include two testicles, which are held in the scrotum. Male sex cells (called sperm) are formed in the testicles. Upon ejaculation, sperm are transported from the testicle through a tube called the vas deferens. The vas deferens empties into the urethra, which serves to excrete both semen and urine. The penis serves as a passageway for semen and urine, and it is the organ of copulation. Semen, the fluid ejaculated from the male, contains sperm cells in fluid from the accessory sex glands (seminal vesicles and prostate). The sperm cells carry genetic information from the male and fertilize the female egg.

Breeding Soundness and Bull Fertility

Fertility of the herd bull is essential to a successful cow-calf operation. In many respects, it is more of a concern than that of the cow since the bull contributes half of the genetic potential of the entire calf crop in comparison to a cow that is expected to wean only one calf per year. Subfertile bulls create low calf crop percentages and can be responsible for poor herd weaning weights. This is evidenced by the fact that for every heat cycle a female

fails to conceive, there is a corresponding decrease in calf weaning weight from 25 to 45 pounds. It does not take long to realize that poor fertility or infertility of a bull can be extremely expensive to the cow-calf producer.

Two factors influence bull breeding performance: libido (sexual drive) and fertility (high quality and volume of semen). Currently, no test exists for determining libido in bulls. Examination of the bull during the breeding season is the only option. Libido is highly heritable and highly correlated with serving capacity. Therefore, bulls with high libido can service more cows. Our only tool to assess bull fertility is the breeding soundness exam (BSE).

Beef bulls should be evaluated for breeding soundness 30 to 60 days before the breeding season is scheduled to begin. A breeding soundness exam helps eliminate losses due to infertility and provides time to replace questionable or unsatisfactory bulls. A breeding soundness evaluation should include:

- A physical examination
- An examination of the reproductive tract
- A semen evaluation.

Physical examination. A thorough physical examination should be conducted to ensure that bulls are capable of locating cows in heat and physically capable of mating. The physical should include an appraisal of body condition. Thin bulls lack stamina necessary to breed and settle cows during a short or restricted breeding season, whereas overly fat bulls lack vigor and fail to realize their breeding potential. Feet and legs should be carefully inspected to identify faults that can impair the bull's ability to travel and mount. Structural problems, including sickle hocks, post legs, and sore feet, can impair breeding performance. Eyes should be clear and free of disease or injury. Bulls should also be evaluated for disease or sickness that might impair breeding performance.

Examination of the reproductive tract. A complete examination of the reproductive tract for disease and abnormalities should be made. This includes rectal palpation of the bull's internal reproductive organs. The external examination includes palpation of the spermatic cord, testes, scrotum, and epididymis. The penis and sheath should also be examined. Hair rings, warts, and other structural damage to the penis will reduce the ability of a bull to breed cows. Scrotal circumference may be obtained at this time. Recommended scrotal circumferences are shown in Table 5-26. Young bulls with an above-average scrotal circumference should produce more sperm cells. University research shows that 63 million more sperm cells are produced for each additional centimeter of scrotal circumference. Scrotal circumference is highly correlated with semen output and semen quality (Figure 5-31). Therefore, bulls with a large scrotal circumference can serve more females than bulls with a smaller scrotal circumference.

Scrotal circumference can be measured by slipping a flexible centimeter tape over the bottom of the scrotum. The tape should be pulled snugly over the widest point of the scrotum with the testicles fully descended. Commercial measuring devices are available. However, a sewing tape can be used in an emergency. Measurements are generally given in centimeters (1 inch = 2.54 centimeters).

Semen evaluation. After collection, the semen is evaluated under a microscope to determine motility (the percentage of sperm that are moving) and whether morphological aberrations are present. Motility is very important for sperm transport and fertilization of the egg. Sperm that is classified as 70% or better for motility is very acceptable. Two types of morphological abnormalities exist in sperm. The first type is malformed sperm heads, while the second type is malformations of the sperm tail. Tail abnormalities are usually the result of poor maturation of the sperm. Often these abnormalities disappear with age and additional collections of the bull. Bulls classified as "Deferred" usually have sperm tail abnormalities, and often these bulls will pass a subsequent BSE.

Table 5-26. Scrotal circumference by age.[1]

Age	Very Good	Good	Fair
12-14 mo.	> 34 cm	30-34	< 30
15-20 mo.	> 36 cm	31-36	< 31
21-30 mo.	> 38 cm	32-38	< 32
over 31 mo.	> 39 cm	34-39	< 34

[1] > = greater than; < = less than.
Source: Spitzer, et al. Breeding Soundness Evaluation on Beef Bulls. Southern Region Beef Management Handbook. ASC-121. Lexington, KY: University of Kentucky Cooperative Extension Service.

Factors That Affect Bull Fertility

Several factors affect bull fertility. Injury can greatly reduce the breeding performance of a bull. Injuries to be aware of are penis abnormalities, which include a broken penis, hair rings around the penis, and structural damage to either the penis or the sheath that prevents extension of the penis. Additionally, the retractor penis muscle may be injured, which would prevent penis extension and contraction.

Genital warts are another common problem. Penile warts are painful and prevent the bull from properly servic-

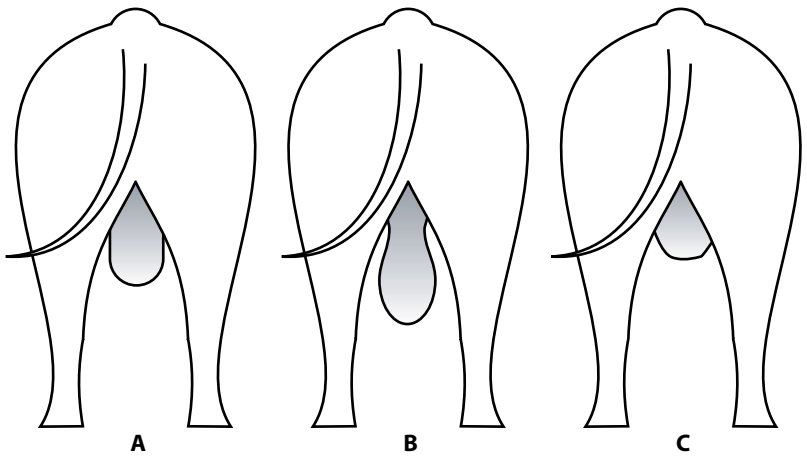


Figure 5-31. Three scrotal shapes seen in beef bulls are the straight-sided scrotum (A), the normal scrotum (B), and the wedge-shaped scrotum (C). Scrotal shapes A and C are the least desirable. Adapted from Cates (1975).

ing the female. Each BSE should include extension of the penis to ensure proper function. Injuries to either the scrotum or the neck of the scrotum can also reduce fertility by preventing the bull from maintaining the proper temperature of the testis.

Health can dramatically influence bull fertility. Any illness that elevates body temperature for 2 degrees for 48 continuous hours renders a bull totally infertile for about 60 days. If the illness is treated early, fertility in the bull is reduced for about 14 days. To limit the impact of illness on fertility, producers need to treat illness in bulls quickly and aggressively.

Nutrition

Nutritional management of bulls from weaning to maturity can dramatically affect bull fertility. Research has demonstrated that bulls fed moderate-energy diets (forage-based) from weaning to yearling had a 52% higher semen output at the same scrotal circumference than bulls fed high-energy diets (starch-based). If fed these diets from weaning to two years of age, the bulls fed the moderate-energy diets had a 300% increase in semen output. The reduced fertility of the bulls fed the high-energy diets was suggested to arise from a higher fat deposition in the scrotum and spermatic cord. The function of the scrotum and spermatic cord is to reduce the temperature of the testis. Sperm production occurs best when the temperature of the testis is about 2 degrees below body temperature. Insulation of the scrotum and spermatic cord via fat deposition could reduce the bull's ability to regulate the temperature of the testis and, therefore, reduce fertility. Researchers observed that bulls fed high-energy diets had surface scrotal temperatures 2.3 degrees higher than bulls fed moderate-energy diets. Additionally, back-fat thickness was negatively associated with pregnancy rates in range bulls. To maintain high fertility, bulls should not be fed such that BCS exceeds 6.

Scrotal shape can be used as an indicator of fertility. Scrotal shape is known to influence testicular development and function. As scrotal shape is a conformational trait, it would be expected to have a high heritability. Three basic shapes have been recognized in the beef bull: normal, straight-sided, and wedge-shaped (Figure 5-31). The normal shape of the scrotum is bottle-shaped. Bulls having a normal scrotal shape with a distinct neck (Figure 5-31, Bull B) generally have the best testicular development and function. This scrotal shape allows for optimal regulation of testicular temperature. Often bulls with a straight-sided scrotal shape (Figure 5-31, Bull A) have only a moderate testicular size. The straight-sided appearance of the scrotum is generally the result of fat deposition and will likely reduce sperm production by ineffective thermoregulation of the testis. Wedge-shaped scrotums (Figure 5-31, Bull C) are pointed toward the apex of the scrotum and tend to hold the testis close to the body. Bulls with this scrotal shape generally have small testes and rarely produce semen of satisfactory quality. For optimal fertility, select bulls with a normal, bottle-shaped scrotum that is well defined and free of fat.

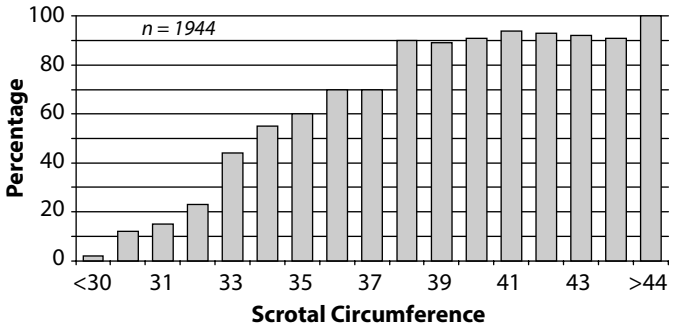


Figure 5-32. Scrotal circumference and seminal output.

Development of Young Bulls

Try to develop young bulls so that they have a good rate of growth, and try to ensure early development of their reproductive capacity without excessive condition. Most bulls are sold at about one year of age and still have a lot of growth and development ahead of them. This is particularly true of today's bulls, which are frequently selected for extra growth.

Most bull sales are held in March and April to allow some time before the start of the breeding season for spring calving. Most of the bulls have been on a fairly high-concentrate diet for more than 100 days as a result of being on a performance-testing program or just because bull buyers prefer bulls in fleshy condition. Whether the yearling bull is fed on the farm or at a test station, most are fed to gain 2.5 to 4.0 pounds per day. After coming off test, they should continue to gain about 2 pounds per day.

Very fleshy young bulls require some conditioning prior to the breeding season. They will have to maintain a high level of physical activity when they are breeding several cows. You can give them plenty of exercise by locating feed and water away from each other in a small pasture. Bulls should be "let down" gradually by decreasing the amount of grain and increasing the amount of roughage in the diet. To keep gain at about 2 pounds per day, feed about 8 to 12 pounds of grain per day in addition to spring pasture, or provide free-choice high-quality roughage with 1 to 1.5 pounds of grain supplementation per 100 pounds of body weight daily.

At the start of the breeding season, bulls should be in good physical condition, fertile, and able to cover considerable distance to keep up with the cows. Over-conditioned bulls lose weight rapidly and may not be as fertile as well-conditioned bulls.

Yearling bulls should *not* be purchased unless they have passed a BSE. If yearling bulls are purchased without a BSE, they should be given one before the start of the breeding season. All bulls should be subjected to a BSE before *each* breeding season. They should be observed closely during the breeding season to see if they are detecting heat and getting the cows bred. If they become too thin, it may be necessary to rest and/or hand feed them.

It is not uncommon for yearling bulls to lose as much as 100 to 300 pounds during their first breeding season. They should gain this weight back and continue to grow so that they weigh about 75% of their mature weight by the time they are two years old. This requires more than

summer grass pasture; however, too much grain too fast can cause founder.

Serving Capacity

Serving capacity of bulls is highly variable and is influenced predominantly by scrotal circumference and libido (Figure 5-32). Serving capacity increases with age because older, more experienced bulls are more efficient. Research has demonstrated that older bulls spend less time with each estrual female and can service more estrual females in a day. Serving capacity is also influenced by social effects. In multiple-sire mating systems, the dominant bull sires a majority of the calves. If the dominant bull is less fertile, breeding performance can be greatly reduced. Multiple-sire systems are most efficient when bulls of similar age, weight, and breed are used. Also, rearing bulls together helps reduce potential problems associated with social dominance.

Traditionally, bull-to-cow ratios of 1:25-30 have been recommended for mature bulls and 1:10-20 for yearling bulls. Some current research indicates that bull-to-cow ratio can be increased if bulls have a large scrotal circumference (> 35 cm at a year of age) and experience. Bull-to-cow ratios of 1:44 and even 1:60 have not reduced pregnancy rates in a 70-day breeding season. However, the bulls used were experienced, *highly fertile,* bulls with *a large scrotal circumference.* Likewise, bull-to-cow ratios had no effect on pregnancy rate when estrus synchronization is used prior to natural service. Bull-to-cow ratios ranged from 1:20 up to 1:42 with no effect. In these trials, *experienced* bulls with *a large scrotal circumference* were used. The traditional bull-to-cow ratios have less risk and should be followed when fertility, libido, and yearling scrotal circumference are unknown.

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Planning the Genetics Program

Darrh Bullock

The quality of cattle produced by the beef industry is determined by the cattle's genetic makeup and the management system to which they are subjected. Genetic makeup is under total control of breeders, both seedstock and commercial, and this responsibility should not be taken lightly. Research has shown that different types of cattle perform differently under varied management conditions. This means that beef producers cannot just select for the maximum in traits of economic importance but that they must match their genetics to their resources and environment.

The selection of bulls and heifers, and the breeding system used, dictate the genetic quality of the calf crop. The seedstock producer uses selection for genetic management, while the commercial producer uses both selection and mating systems, especially crossbreeding.

Because most sires are purchased from them, seedstock breeders exert a great influence on the direction of the beef industry. Commercial producers are insisting that the seedstock producer keep records and make these records available. It is important that both seedstock and commercial producers understand and use the principles and tools of genetic improvement.

Goals and Targets

Having goals that you intend to meet is important for many areas of beef production but may be most critical for the genetics program. These goals may include reproduction, calf performance, income, cost containment, or a number of others. Genetic management decisions will impact each of these goals to varying degrees. The breeding management practice that has the greatest impact on reproduction would be crossbreeding, whereas selection is the best management practice for improving carcass quality. Set goals for your beef herd that are important to your family's quality of life and then determine which management and breeding practices will best help you to attain those goals. Remember, most management decisions can be changed in an instant, but changes to your herd's genetics generally take time.

The beef cattle industry is segmented, with many cattle having three or more owners before arriving at the grocer or restaurant. This type of system has its drawbacks for the industry as a whole, but it does allow some opportunities. When considering your breeding program, you must consider when you plan to market your cattle (weaning, preconditioned, yearling, finished) and what kind of product you are trying to produce.

The most common opportunities to market cattle intended for meat production are:

Newly weaned calves sold at auction. Buyer has little to no knowledge of calves other than what is seen in the flesh.

Newly weaned calves sold off the farm. Buyer has direct contact with the producer and is potentially more aware of performance information to varying degrees, breed type, and management information.

Calves sold either at auction or off the farm after preconditioning at least 45 days postweaning. This marketing system is most effective when the buyer is aware of the preconditioning; therefore, if calves are sold at auction, it is generally best to sell in a special preconditioned sale (i.e. Certified Preconditioned for Health–CPH-45) or at a minimum announced at the auction.

Yearlings sold after backgrounding either at auction or off the farm. Buyer generally has little knowledge of the cattle, but older cattle tend to have better health as feeders compared to calves.

Retained ownership through feedyard to finish. Once the cattle have reached their finished condition, there are additional options:

- **Sell live as commodity cattle.** This basically means you take the live-price of finished cattle being offered at that time.
- **Sell on the rail (grid or formula).** This is a precise system that pays premiums for certain types of cattle. Some grids are better suited for high-quality grade cattle, and others are better suited for better yield grading cattle.

Finished and sold locally. This option is becoming more common and allows for the greatest control of the entire process. Selection can be used to target specific needs of customers.

When and how you plan to market your cattle play important roles in your breeding decisions.

There is not a right or wrong answer to when and how to market cattle. Depending on your resources, one option may be better than another, but certain situations may cause you to consider one of the other options. Some examples of situations that may cause you to re-evaluate how you market your cattle would be drought or other restrictions to grazing management, market and/or futures prices, alternative feed availability, or others. Although it is important to set goals and have targets, it is also important to be flexible if opportunities or adversities develop.

Herd Assessment

Once your goals have been established, and you have a target for which you are shooting, it is important to determine the performance level and potential of your current herd. When going through this process, it is very important to be honest with yourself and examine your operation with a critical eye. You may find that your herd is performing at the appropriate level for the management that you have, or you may find that you need to make some drastic genetic changes in order to meet your goals.

The first step in the herd assessment process, for a commercial producer, is to determine the breed makeup of the herd. This will tell you whether you have been doing a good job of crossbreeding. As a general rule, if you have cows in the herd that are greater than 75 percent of one breed, you should make some changes to

your breeding program to take advantage of crossbreeding. This will be discussed in greater detail in the crossbreeding section below.

The next step is to determine the production level of your herd. You must keep good records. With good records, you will be able to assess the reproductive performance (including calving distribution), sickness, growth performance, cow condition at weaning, and any other characteristics that you keep records on. Having this information will help you determine if changes are needed and help you determine how best to make those changes. If you do not currently keep good records, see Chapter 12: Record Keeping for Management Decisions and start a record-keeping program. Without records, you can still assess your herd for other factors, but you will be drastically limited.

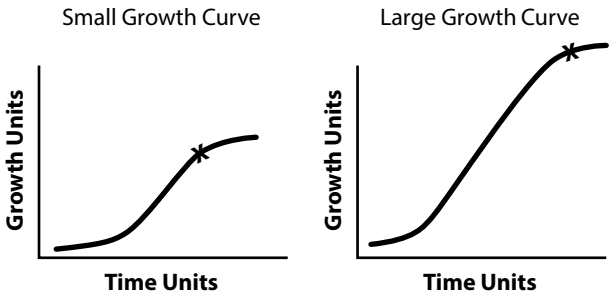
The last step in this process is determining the size of your cows. The mature weight of the cow determines how much nutrition will be required to meet her maintenance needs. The larger the cow is the greater amount of nutrition is needed to sustain her body condition and thus future reproduction. Frame size can give a rough estimate of a female's future size, but there is no substitute to weighing cows to determine their size and nutritional needs.

Frame's Effect on Feedlot Performance and Carcass Weight

The growth and development relationship between large- and small-framed cattle can be observed in Figure 6-1. The growth pattern of the different types of cattle is similar, and the X illustrates the optimal finish point for the cattle. This is the point where most breeds have the opportunity to grade a minimum of low choice on the USDA Quality Grade scale. This is typically achieved when the cattle's fat thickness over the ribeye is approximately .45-.50 inches. At this point, the cattle are starting to accumulate fat at a more rapid rate. Since it requires more feed to put on a pound of fat than a pound of muscle, the cattle become less efficient in feed to gain conversion.

As a general rule, larger-framed cattle tend to grow at a faster rate; however, they reach their optimal finish point later and at heavier weights. The implications are that larger-framed cattle require more feed to finish and have greater expenses due to a longer period in the feedyard; however, they are heavier at finish which will generate more income. As long as cattle do not fall into the light or heavy carcass category, the trade-off is probably similar. The real problem occurs when cattle of varying frames are fed together to a constant endpoint. The average of the group will meet industry needs, but there will likely be a number of over- and under-finished cattle in the group. Grouping cattle according to type going into the feedyard or sorting the cattle out as they finish is essential to producing a uniform, acceptable product.

Figure 6-1. Growth curve comparison of small- vs. large-framed cattle.



Management Assessment

Management is another component of your operation to assess. To determine the genetic type of cattle that you need, it is important to know what resources are available and how that affects the performance of your herd. When assessing management concerning establishing the proper level of genetics, the primary areas of concern are labor and nutrition availability.

Labor

In the context of genetic impact on the herd, labor is defined as the frequency and duration of time spent with the cowherd during calving season. Using this definition, labor is an important component when determining your breeding program. Determining how closely the cattle will be monitored during the calving season will have a major influence in determining how much calving ease is needed in the bulls or semen being purchased. In other words, are you a full-time farmer who spends a great deal of time with the cattle and can provide assistance when needed, or are you a part-time farmer who gets the opportunity to see the cattle only on occasion and whose cattle are required to be more self-sufficient during calving? Knowing this information can assist in developing a breeding program. As an example, a full-time farmer who observes the cattle multiple times in a day might choose to lessen restrictions on calving ease in favor of more production, whereas the part-time farmer who has limited observation of his cattle must use a calving ease bull to minimize calving difficulty.

Example of Calves from a Large-Framed Bull and a Moderate-Framed Bull with the Same EPDs for Growth

If two bulls have the same genetics for growth but differ in frame, we would expect the larger-framed bull's calves to be taller at weaning and as yearlings, the finished calves to be heavier and take longer to feed to optimal finish, and the females to be larger as mature cows. However, because the bulls have the same Expected Progeny Differences (EPDs) for growth, we would expect the calves to weigh the same at weaning and as yearlings. If large- and moderate-framed calves weigh the same, the larger-framed calves likely have less muscling and/or less body capacity. To put this into perspective, compare a 6-foot 8-inch person who weighs 250 pounds, with a 5-foot 8-inch person who weighs 250 pounds; the taller person is likely to be leaner with less girth.

Nutrition

The availability and quality of nutrition are extremely important when determining your breeding program. Different types of cattle perform differently depending on the nutrition that they receive. Research has shown that under

nutritionally stressful situations, smaller, less-productive cattle are more efficient at turning the resources available into pounds of salable product. Their calves are still smaller on average, but they tend to have higher reproduction rates that offset the deficiency in individual calf weight. Under ideal nutrition, there were very little efficiency differences between high-performing cattle and moderately performing cattle. In an environment that provides abundant nutrition, the larger, high-performing cattle were the most efficient at producing pounds of weaned calves. Based on this information, operations that provide exceptional nutrition should consider more productive types of cattle; however, operations with restricted nutrition, either in availability or quality, should consider less-productive cattle (smaller and/or less milking ability).

Nutrition assessment should include forage base (infected fescue with sparse legumes, high-quality grass/legume mix, cool-/warm-season grass mix, etc.), the nutritional quality of stored feeds (silage, hay harvested and stored correctly, hay harvested after optimum maturity and stored outside on the ground, etc.), and economical availability of purchased feedstuffs. Quantity and quality of feed resources will be a factor in many management decisions, including breeding management.

Genetic Principles

To fully understand breeding management, it is important to know some basic genetic principles. Knowing the role genetics plays in each economically important trait of beef cattle can assist in making wise selection decisions. It is necessary to know which traits can be altered through breeding management (selection and/or crossbreeding) and which traits should be altered by other management techniques.

Most traits of economic importance (calving ease, weaning weight, etc.) in beef cattle are controlled by two factors: the environment in which the animal lives and the animal's genetic makeup (genotype). The environment consists of not only the weather but also how the cattle are managed. Creep feed, forage quality and quantity, and health programs are examples of environmental effects. Environmental effects on economically important traits are impacted by both genetics and other management programs, such as nutrition and health, which are discussed in other chapters of this manual.

The two types of genetic effects on economically important traits of beef cattle are additive and non-additive. When a bull and cow are mated, each contributes 50% of its genetics to their calf. If that calf is then allowed to reproduce, it passes 50% of its genetics to each of its calves; however, each calf gets a different sample of genes from its parents (that is why siblings are genetically similar, but not identical). When the alleles from the parents combine they can behave in one of two ways: the first is that the heterozygous condition is the average of the two homozygous conditions and these effects are called additive. This type of effect will consistently pass from one generation to the next and is therefore the basis for using selection to make genetic improvement. When the combined alleles are non-additive it is difficult to predict how the next generation will perform.

Heritability, the percentage of each trait controlled by the additive genetic effects, is an important factor when making selection decisions. To visualize this better, offspring have more of the same characteristics as their parents for highly heritable traits. In other words, the genetics that caused the parents to perform in a certain manner would be passed on to the calves and they would perform similarly. Highly heritable traits respond more rapidly to selection, while lowly heritable traits respond more rapidly to management practices (environment) and heterosis (crossbreeding). Table 6-1 illustrates the relative heritability and heterosis of several economically important traits.

Another genetic effect that is important when making selection decisions is genetic correlations. A genetic correlation occurs when you select for one trait and another trait is affected. The effect of one trait on the other can be either complementary or disadvantageous. Here is an example of a complementary genetic correlation: As selections are made for increased weaning weight, yearling weight is also increased. An example of a disadvantageous correlation is: As selections are made for increased weaning weight, birth weight increases and calving ease decreases. Genetic correlations work the same regardless of which trait is being selected for. In other words, as selections are made to decrease birth weights, weaning and yearling weights are usually decreased, too. The implications of genetic correlations for many traits for which Expected Progeny Differences (EPD) are calculated are discussed below and in Table 6-2.

Non-additive genetic effects refer to how the genetics from the two parents combine and how they interact with the environment. The best example of non-additive genetic effects are the benefits realized from crossbreeding. These benefits are known as heterosis. Heterosis is

Table 6-1. The relative heritability and heterosis effects of several economically important traits in beef.

Trait	Heritability	Heterosis
Birth weight	moderate-high	moderate
Calving ease	moderate	moderate
Weaning weight	moderate	moderate
Yearling weight	moderate	moderate
Milking ability	moderate	moderate
Carcass traits	high	low
Reproduction	low	high
Longevity	low	high

Table 6-2. Selection based on EPDs.

	Birth weight	Weaning weight	Yearling weight	Milking ability	Calving ease	Mature size
CED EPD	-	-	-	0	+	0
WW EPD	+	+	+	-	-	+
YW EPD	+	+	+	-	-	+
Milk EPD	0	-*	-*	+	0	0

+ = As EPD goes up, this trait also tends to increase.
- = As EPD goes up, this trait tends to decrease.
0 = No relationship.
* Increased milk EPDs result in decreased growth rate for the first generation. Due to added milk production, offspring of first-generation females have increased WW and YW.

defined as the increase in productivity in crossbred offspring over the average of breeds that are crossed. Heterosis is highest for lowly heritable traits (such as reproduction) and lowest for highly heritable traits (such as carcass traits) (see Table 6-1 for the impact of heterosis on several traits). Crossbreeding might result in relatively small amounts of heterosis for each trait, but these effects tend to accumulate to produce large increases in overall productivity. In some instances, a portion of this advantage is passed on to future generations, but to optimize the benefits, a crossbreeding system should be designed and maintained.

Coat Color and Polled/ Horned/Scurred

For most traits that we deal with in cattle, the genetic contribution is provided by many gene pairs, and the environment contributes significantly to how the cattle perform. Two exceptions to this are the traits of coat color and polled/horned. To know how color and horns occur, it is important to understand a few concepts.

Color: Black/Red/White/Mixed

For marketing reasons, not production reasons, coat color has become increasing important in selection decisions. It is important to remember that coat color does not impact any economically important traits. In other words, black cattle are not more likely to grade choice, white cattle are not more likely to grow faster and red cattle are not more likely to produce more milk. However, when calves are sold there are differences in value due to coat color, so it is justified to consider coat color when selecting bulls.

In most cases the primary color of cattle is determined by one pair of genes and the result is either red or black. Cattle of most breeds can have either black or red coat color with the exceptions being Charolais and Shorthorn, which will be explained later, and a few grey breeds. The black allele (specific form of a gene) is dominant to red allele which means if a calf has two black alleles, we call it homozygous black (resulting in a black calf); if it has two red alleles, it is called homozygous red (resulting in a red calf); if it has one of each, it is called heterozygous (resulting in a black calf because the black allele is dominant). Another term for heterozygous cattle is carriers, because they are carrying the unobservable recessive allele. In the case of Charolais, in addition to the black/red gene they have what are called diluter genes which cause the animal to repress the coat color genes resulting in white to off-white cattle. When Charolais are crossed with colored cattle the result is generally a smoky or reddish-white color. Shorthorn cattle can have red and white color alleles; two red alleles results in red cattle, two white alleles results in white cattle and cattle with one red and one white allele are red-roan or a blend of red and white hairs. Color patterns, such as white or blazed face, white points, white belts, spots and various others are controlled by genes at other loci (locations in the genome) and are typically breed specific.

From a practical standpoint we can manage coat color through a planned breeding program. Without a planned breeding program the result is usually variation in coat color with some red, black and various other colors showing up. If the desired coat color is red then the breeding program is simple, breed a red bull to red cows and you should always get red calves. Black cows bred to a Charolais bull will always result in smokey colored calves. To get all black calves it typically takes a little more effort. Since black is dominant to red then simply breeding a black bull to black cows does not guarantee black calves. In Figure 6-2, a heterozygous black bull is mated to a herd of heterozygous black cows; in this case 25% of the calves will be homozygous black, 50% will be heterozygous black, but 25% will be homozygous red. The only way to ensure that all calves are black is to breed to a homozygous black bull. Figure 6-3 illustrates that even the extreme case of breeding a herd of red cows, if a homozygous black bull is used, then all of the calves will be black (note: all calves are carriers of the red allele).

Polled/Horned/Scurred

The polled, horned, or scurred condition is less well understood, but can be managed to some degree. Horned feeder calves are not desirable; they are potential hazards for other cattle and the humans working them. For this reason calves with horns are discounted at the sale barn and even though scurs pose no danger to other cattle or humans they are still discounted by many buyers. To minimize these discounts beef producers attempt to use breeding techniques to generate polled cattle or dehorn/de-scur their calves. If you plan to breed for polled cattle it is important to understand the genetic action of the poll/horn gene, however, you will learn that avoiding horns is relatively easy, but avoiding scurs can be much more difficult.

Poll/Horn Gene

In most cattle the horn/poll gene action is simple recessive with the poll allele (P) being dominant to the horn allele (p). Every parent has a pair of genes and they pass one of these genes to their calf; the calf gets one allele from the bull and one allele from the cow to make its pair. What this means is that if a calf gets a polled allele from either parent then it will be polled. If it gets two polled alleles it is considered homozygous polled; if it gets one polled and one horn allele it will be physically polled, but it will be referred to as heterozygous polled or a carrier; if it gets two horned alleles it will be homozygous horned and will grow horns (Figure 6-4).

Since polled is dominant to horned, if you mate a homozygous polled bull to a group of females then all of the offspring will be polled. This is shown in the most extreme case in Figure 6-5 where a homozygous polled bull is mated to a herd of horned cows. In this case 100% of the calves are heterozygous polled, in other words they are physically polled, but carriers of the horn allele. In Figure 6-6, a heterozygous polled bull (Pp) is mated to heterozygous polled cows (Pp). In this mating it is expected that 25% of the calves will be homozygous polled, 50% are expected to be heterozygous polled and 25% to be homozygous horned. This means about 75% of the calves will be polled and 25% horned, even though the bull and cows were all polled.

Reference to poll in this section means the absence of horns, the cattle could be scurred which will be discuss next.

Scur Condition

Unlike the poll/horn trait, scurs is not a simple recessive trait and is not completely understood! It has been hypothesized that the scur condition is controlled on a dif-

ferent gene than the poll/horn gene, but interacts with the poll/horn gene, and it is possibly sex influenced. It has also been theorized that scurs are simply a condition of the poll/horn gene that is sex influenced. It has been shown that, regardless of the cause, the scurs condition can only happen in heterozygous polled cattle, of either sex. The data also support that males develop the scur condition at a higher rate than females. It is postulated that this is due to males expressing scurs when either homozygous or heterozygous for the scur allele and females only have the scur condition when homozygous for the scur allele. However, if there is no actual scur gene, but a sex by poll/horn gene interaction, it is theorized that male hormones could play a role in heterozygous males having an increase in the scur condition compared to heterozygous females.

The condition that is obvious is that horned cattle (pp) cannot have the scur phenotype. If cattle have the genotype for the horned condition (pp) they will always be horned. For cattle to develop scurs, it must be a horn allele carrier (Pp) and have some other unknown genetic influence, realizing that male calves will tend to develop scurs at a higher rate than females. For cattle to be smooth polled it must be either homozygous (PP); or heterozygous polled (Pp) without the unknown genetic influence that allows scurs. Figure 6-4 shows all possible combinations of the poll/horn alleles and where scurs can occur.

Genomics Testing and Planning a Breeding Program to Minimize Horns and Scurs

Genomics tests are available to determine if polled cattle are carriers of the horn allele, but there are no genomics tests for scurs. From a practical standpoint, if you have cattle that develop scurs then it is known that they are carriers of the horn allele and testing is not necessary, however, the lack of scurs does not conversely mean that they are not carriers, they would need to be tested. A common misconception is that a homozygous polled bull should not have scurred calves; it eliminates the possibility of horned calves and reduces the incidence of scurs, but they can occur. If he is bred to cows that have the horn allele then it is possible for him to produce scurred calves. Bottom line, it is easy to breed for polled cattle, buy a homozygous polled bull and you will not have any horned calves (double polled is not the same as homozygous; see glossary). Scurs, as you now know, is a completely different story; buying homozygous polled bulls will assist in reducing the incidence of scurs, since the horn allele is necessary to produce scurs. Until the genetic cause of scurs is determined and a genomics test for the scur allele is developed, if possible, then scurs will be difficult to eliminate.

Crossbreeding for the Commercial Producer

Crossbreeding is the mating of cattle of different breeds or breed composition. It can be an effective method of improving beef production. The two primary reasons to use crossbreeding are (1) heterosis (hybrid vigor) and (2) breed complementarity (breeds have characteristics that complement each other and fit the environment). When crosses are made, one breed's strength can complement the other's weaknesses. Since no one breed is superior in all traits, a planned crossbreeding program can significantly increase herd productivity.

The two greatest economic impacts on profitability from heterosis is the increase in production and longevity of the cows. When production is measured as weaning weight per cow exposed—which takes into account reproductive rate, survival, milking ability, and growth—the increase is between 20 and 25% when compared to straightbred cattle. That means that by maximizing crossbreeding, the effects of heterosis alone can add 20 to 25% more income. The benefit of increased longevity should not be underestimated either. Crossbred cows will stay productive in the herd longer. Cows are the most productive when they are between five and 10 years of age. From an economic standpoint, it is best to have as high of a percentage of the cow herd in the five- to 10-year age group and minimize the number of replacement heifers that are retained each year. This goal is enhanced through crossbreeding. Even if crossbreeding is not maximized, utilizing a system that eliminates cows with greater than 75% of any one breed will make the effort worthwhile.

	Black Bull ♂ B	Black Bull ♂ b
Black Cows ♀ B	**BB** *black*	**Bb** *black*
Black Cows ♀ b	**Bb** *black*	**bb** *red*

Figure 6-2. Mating a heterozygous black bull to heterozygous black females and the possible genotypes and phenotypes of the calves.

	Black Bull ♂ B	Black Bull ♂ B
Red Cows ♀ b	**Bb** *black*	**Bb** *black*
Red Cows ♀ b	**Bb** *black*	**Bb** *black*

Figure 6-3. Mating a homozygous black bull to homozygous red females and the possible genotypes and phenotypes of the calves.

Genotype	Phenotype
PP	Polled
Pp	Polled (scurs possible*)
pp	Horned

Figure 6-4. Possible genotypic combinations and phenotypic appearance of cattle for the poll(P)/horn(p) gene in cattle.
*Expect a higher incidence in males than females.

	Polled Bull ♂ P	Polled Bull ♂ P
Horned Cows ♀ p	**Pp** *polled**	**Pp** *polled**
Horned Cows ♀ p	**Pp** *polled**	**Pp** *polled**

Figure 6-5. Mating a homozygous polled bull to homozygous horned females and the possible genotypes and phenotypes of the calves.
*Possibly scurred.

	Polled* Bull ♂ P	Polled* Bull ♂ p
Polled* Cows ♀ P	**PP** *polled*	**Pp** *polled**
Polled* Cows ♀ p	**Pp** *polled**	**pp** *horned*

Figure 6-6. Mating a heterozygous polled bull to heterozygous polled females and the possible genotypes and phenotypes of the calves.
*Possibly scurred.

Breed complementarity has to do with the breeds that you choose to go into your cross. Finding a combination of breeds that will perform optimally in your environment (management) is critical in developing a successful breeding program. Producers with high management, particularly in nutrition quantity and quality, can utilize high-producing breeds more efficiently than producers that have limited nutrition. Most Kentucky operations would probably be considered moderate in their ability to provide adequate nutrition to their cattle. Under normal conditions, the cattle do very well and maintain an adequate level of condition. However, under adverse conditions, such as drought or harsh winters, the nutrition level is not adequate to maintain condition, and reproductive performance suffers. In general, moderate production levels in the cow herd are what most Kentucky operations can sustain.

To achieve the level of production that is desired, a combination of breed selection and bull selection within the breed can be utilized. Selection can be based on heritable traits, such as growth, while crossbreeding enhances lowly heritable traits such as reproduction. Figure 6-6 shows the relative importance of both selection and crossbreeding in an improvement program. Do not think that if you use crossbreeding you no longer need to buy good bulls. Conversely, do not think that buying good bulls will offset the benefits of crossbreeding. Crossbreeding and selection are complementary and should be used in tandem in commercial herds (see Figure 6-7).

Crossbreeding Systems

Crossbreeding systems must be planned for each operation, depending on herd size, potential market, level of management, and facilities. A long-term plan is necessary to gain maximum benefits from crossbreeding. The advantages and disadvantages of various crossbreeding systems are listed below.

Two-Breed Terminal Cross

This system uses straightbred cows and a bull of another breed. It is considered a terminal cross because all calves are sold and no replacements are retained. An example would be Charolais bulls bred to Angus cows. In this system, replacements must be bought from another source. This is not a desirable system because it does not realize any heterosis in the cow since she is a straightbred (Figure 6-8).

Three-Breed Terminal Cross

This system uses a two-breed cross (F1) cow and a bull of a third breed. It produces maximum hybrid vigor in the cow and calf. This is an excellent system because hybrid vigor is realized for the calf directly and through maternal traits of his crossbred dam. Replacement females for this system must be purchased or raised from another source. This is a good system for any size herd if high-quality replacement females are available.

Two-Breed Rotation or Crisscross

This is a simple crossbreeding system involving two breeds and two breeding pastures. A two-breed rotation is started by breeding cows of breed A to bulls of breed B. In each succeeding generation, replacement heifers are bred to bulls of the breed that is the opposite of their sire (see Figure 6-9). Two breeds of bulls, and a minimum of two breeding pastures, are required after the first two years of mating.

Three-Breed Rotation

This system follows the same pattern as the two-breed rotation, but a third breed and pasture are added (Figure 6-10). The three-breed rotation maintains a higher level of hybrid vigor than the two-breed system. Mating plans can be confusing, but individual cows are not moved from one breeding group to another. Three distinct groups of cows are eventually created, and they are mated to the sire breed to which they are least related. This scheme continues for the life of the cow.

Rotational-Terminal Sire Combination

This system involves the use of rotational mating of maternal breeds (breeds A and B) in a portion of the herd to provide replacement females for the entire herd (Figure 6- 11). The older crossbred

Figure 6-7. Role of selection and crossbreeding in determining level of performance.

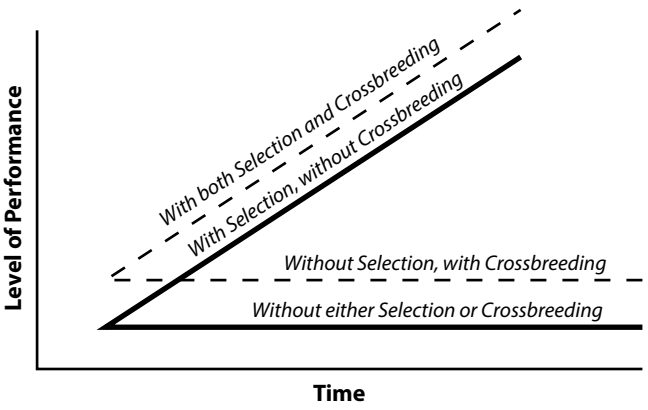


Figure 6-8. Terminal cross.

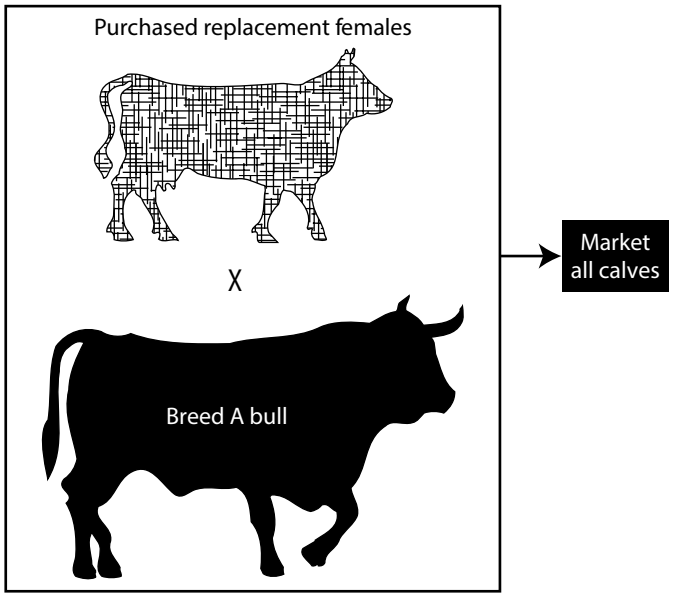


Figure 6-9. Two-breed rotation.

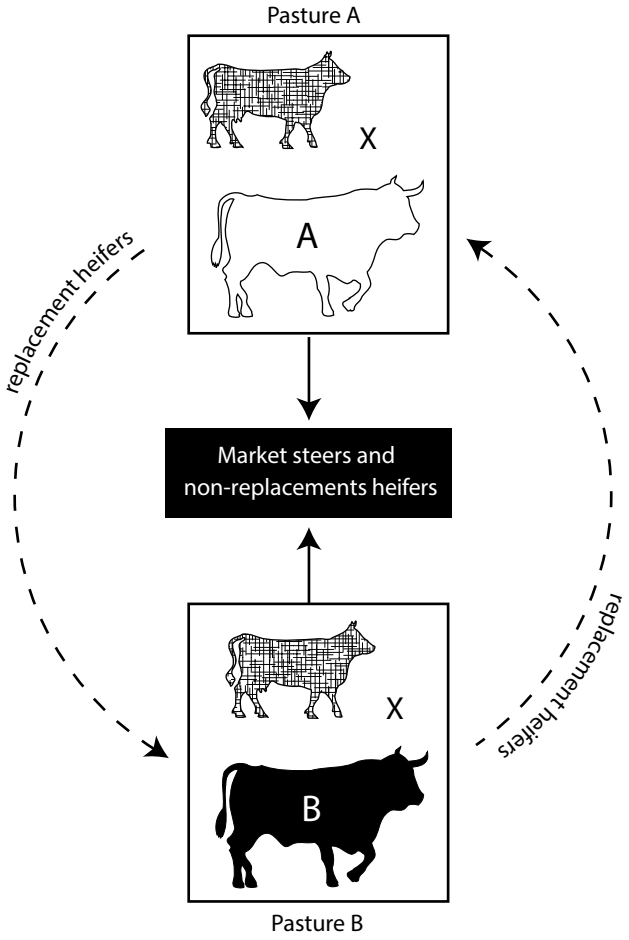
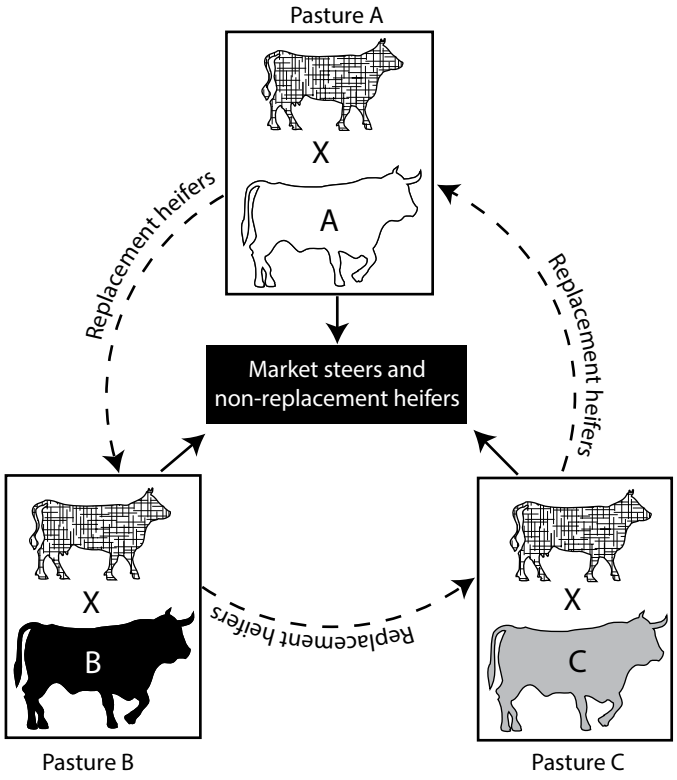


Figure 6-10. Three-breed rotation.



cows are then mated to the terminal sire breed (Breed C). All of the terminal cross offspring are marketed. This system maintains a high level of production but also requires a high level of management.

Heifers out of Heifers

This is a specific example of a rotational-terminal sire combination. There is no foundation to the argument that you should not keep a heifer out of a heifer. In contrast, this system is one of the best available to maximize efficiency. In herds that have more than one bull or where AI is a possibility, this is a productive crossbreeding system. Breed all heifers and enough younger females to total about two-and-a-half times the number of replacement females you plan to keep the next year to an easy-calving, maternal bull. For example, if 10 replacement females are desired the following year, breed 25 heifers and young females to the bull. Select all replacement heifers out of this group of calves. Breed the rest of the herd (older cows) to a high growth, heavy-muscled terminal bull, and market all of the calves (refer to three-breed terminal cross). This system allows the producer to get easy calving in the first-calf heifers and good maternal characteristics in the replacement heifers and to maximize growth and muscling in the majority of the feeder calves. The only drawback is the nonconforming steers out of the heifers and young cows, but the benefits are typically worth it.

AI Roto-Terminal

This system usually uses a very strict synchronization program, and all cows and heifers are mated to a maternal-type/heifer-acceptable bull, using artificial insemination (AI). All cows (excluding virgin heifers, unless the terminal bull is also heifer acceptable) are then exposed to a terminal type bull (Figure 6-12). Virgin heifers that do not conceive by the first mating can be inseminated a second time, or a larger number of replacements will need to be retained through pregnancy testing each year. Heifers are only retained from the AI matings.

Modified Crossbreeding

In many herds, the facilities and level of management required to use intricate crossbreeding systems are not available. However, with some modification, you can use some of the basic crossbreeding principles. Here's how to simplify the traditional systems:

Purchase crossbred females. This is the simplest and fastest method of obtaining maximum hybrid vigor. Purchased two-breed cross females can be bred to a terminal sire of a different breed; this maximizes both individual and maternal hybrid vigor. The producer needs an available supply of high-quality, disease-free females.

Use bull-breed rotation. This involves using a bull of one breed for a set number of years (recommendation of four years), then rotating to a different breed of bull.

If a balance between good feeder calves and good replacement heifers is desired, switching between breed types is also desired. In other words, use a British breed bull for four years, then switch to a Continental breed for four years, then switch back to the original breed. Try to save a larger number of replacement heifers in years that a maternal-type bull is used. Only one breeding pasture is required, and replacement heifers are generated within the herd. This system sacrifices some hybrid vigor when compared to a two-breed rotation, but it is simple and practical for many producers.

Selection

Selection refers to the breeder's decision to use some animals as parents and to cull others. For selection to be most effective, breeders must be able to identify superior animals. This is done by placing emphasis on economically important traits that are heritable (see the "Genetic Principles" segment of this chapter). "National Cattle Evaluations," which compute genetic information (Expected Progeny Differences) on various traits, are available from most breed associations and are useful in making selection decisions. By using AI, the average producer can select a bull of proven breeding value from the "national" herd rather than using one of lesser quality, but this is not required to get good quality bulls.

Bull Selection

Bull selection is one of the most important decisions you will make as a cow-calf producer. The bull is generally thought of as "half the herd" because he contributes half the genetic makeup to each calf crop. However, in herds where replacement heifers are retained, approximately 87.5% of the genetic makeup of each calf comes from the last three generations of bulls used. Therefore, the importance of selecting bulls genetically suited to your operation cannot be overemphasized.

The first decision to make when selecting a bull is which breed or breed type to use. Producers usually have strong feelings about the merits of their favorite breeds of cattle. However, no breed

Figure 6-11. Rotational-terminal combination.

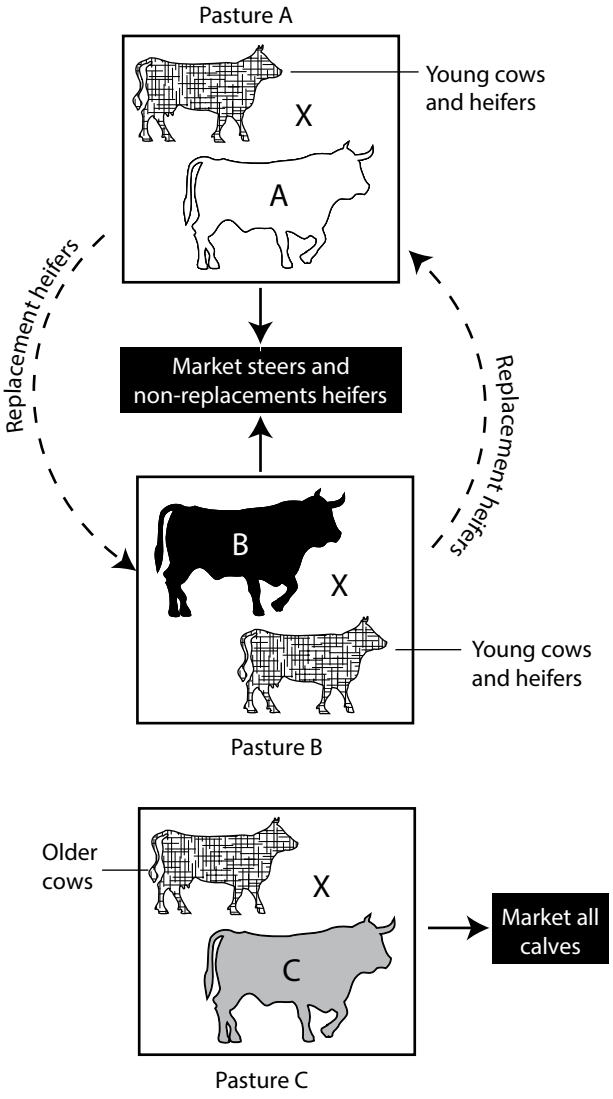
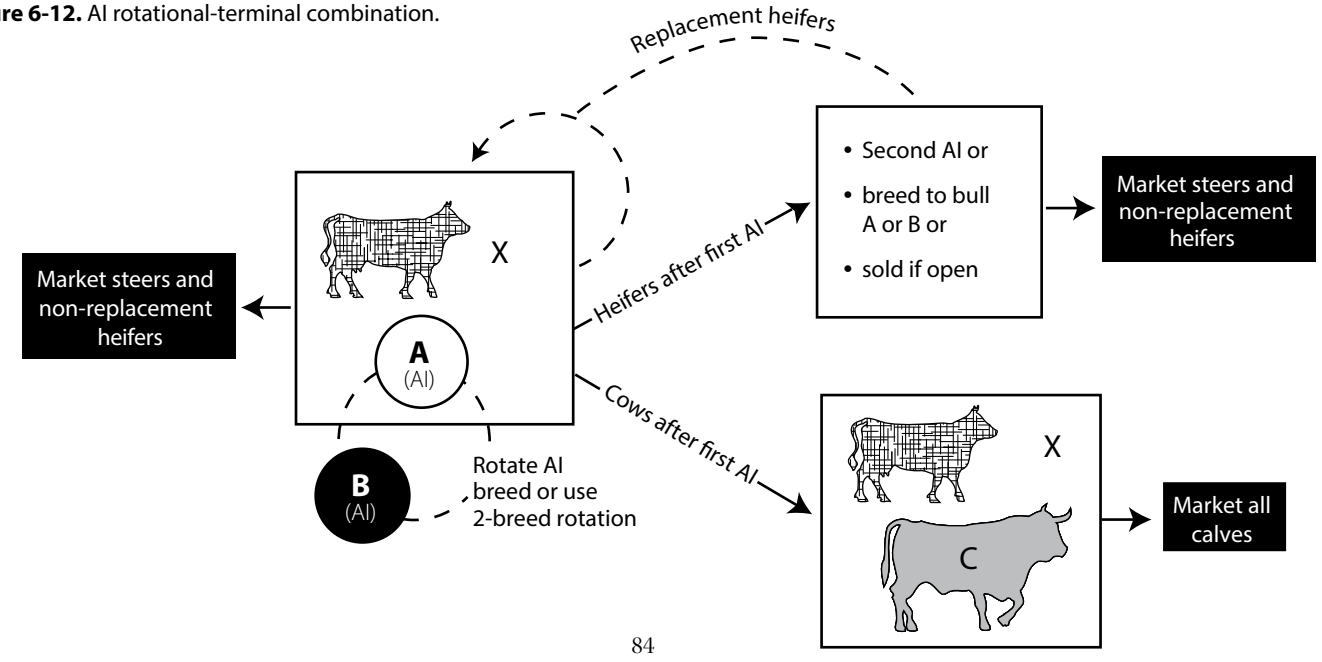


Figure 6-12. AI rotational-terminal combination.



excels in all traits. It is important to know the relative strengths and weaknesses of various breeds so you can plan mating systems in which breeds complement each other and fit your environment.

Knowledge of some general characteristics of breed types is helpful in planning. British breeds (those that originated in the British Isles, such as Angus and Hereford) generally have good fertility, good disposition, moderate birth weights, moderate to high growth and mature size, and grade well at acceptable finish weights. Continental breeds derive from two primary uses; meat and milk (such as Simmental and Gelbvieh) or meat and work (such as Charolais and Limousin). These breeds can have heavier birth weights, are fast growing with large mature size and tend to have leaner carcasses unless fed to heavier weights. The meat-milk breeds tend to have extreme amounts of milk and the meat-work breeds tend to be lighter milkers, are leaner and reach puberty at later ages. American breeds (primarily of Brahman origin) are moderate in growth traits and have better heat tolerance and longevity than other breed types, but can have difficulty reaching puberty at an acceptable age when a high percentage of Brahman breeding is used.

Select a breed or combination of breeds to use in your beef program based on the following:

- Goals of your operation
- Marketability in your area
- Cost and availability of good seedstock
- Climate
- How breeds complement each other
- How breeds fit your environment
- Personal preference

Table 6-3 indicates the level of production of some breed crosses, based on growth rate and mature size, lean-to-fat ratio, age at puberty, and milk production.

A sire breed in a crossbreeding program might have the following characteristics: rapid growth rate, moderate to thick muscling, and adequate calving ease. A dam breed might have these characteristics: high fertility, good milking ability, and small to medium mature size. Since no breed possesses all of these characteristics, some compromises must be made when selecting breeds for a crossbreeding program.

Table 6-3. Some breed crosses grouped into production types.

Breed Group	Growth Rate and Mature Size	Lean-to-Fat Ratio	Age at Puberty	Milk Production
Jersey	+[1]	+	+	+++++
Angus	+++++	++	++	+++
Hereford	++++	++	+++	++
Red Poll	++	++	++	++++
Shorthorn	++++	++	++	+++
Tarentaise	+++	+++	++	+++
Pinzguaer	+++	+++	++	+++
Brahman	++++	+++	+++++	+++
Braunvieh	+++	++++	++	++++
Gelbvieh	++++	++++	++	++++
Simmental	+++++	++++	+++	++++
Maine Anjou	+++++	++++	+++	+++
Limousin	+++	+++++	++++	+
Charolais	+++++	+++++	++++	++
Chianina	+++++	+++++	++++	+

[1] + = low, +++++ = high
Source: Encyclopedia of Animal Science – Beef Cattle: Breeds and Genetics. Cundiff, 2003. Angus Growth Rate and Mature Size modified by Bullock 2019, based on MARC data.

Once you have chosen a breed, it is time to select a bull within that breed. Use four basic criteria when selecting a bull: structural soundness, reproductive soundness, performance information, and visual appraisal.

Structural Soundness

Structural soundness is important if bulls are to travel distances to keep up with cows and be able to mount them (especially if they are expected to breed a large number of cows in a short time). Beware of the following problems: rear legs that are too straight (post legs), rear legs too close at the hocks with too much angle (cow hocked), corns, and abnormal hoof growth (evidence of founder). Structural soundness should be assessed in regard to its impact on function; a minor flaw that will not affect a bull's performance should not be grounds for overlooking the bull. Structure is a heritable trait, so a bull with poor structure can pass this undesirable trait to his daughters and if they are retained as replacements it may decrease there longevity. If the bull is going to be used in a strictly terminal system (no heifers retained), less emphasis can be placed on physical soundness, but it cannot be ignored.

Reproductive Soundness

Reproductive efficiency is best measured at this stage by a breeding soundness evaluation (BSE). (For a complete discussion, see Chapter 5: Managing Reproduction). A bull should have passed his BSE, or the seller should be willing to guarantee that he will before you proceed with the selection process.

Performance Information

When purchasing a herd bull, emphasize the genetics that animal will pass on to its offspring, not on how that animal performed. There are three pieces of information that can be used to evaluate bulls based on performance: actual measurements, contemporary group ratios, and Expected Progeny Differences (EPD).

Actual or Adjusted Measurements

The easiest method of performance evaluation is simply comparing animals' actual or adjusted measurements. Unfortunately, this is a poor method of performance evaluation because the environment contributes largely to the animal's measurement. Raw or even adjusted figures on most economically important traits are not very valuable in bull selection. For example, if you are considering a bull and all you know is that he had a weaning weight of 600 pounds, you do not have much information to base your selectin decision. He could have been raised by a heifer on drought-stricken pasture

and have superior pre-weaning growth genetics, or he could have been raised by a mature cow on lush pasture with plenty of creep feed and actually have poor genetics for pre-weaning gain. Environmental conditions play a large part in a calf's actual measurements but have no effect on their future offspring. Selecting cattle based on actual or adjusted measurements should be the last alternative, and information on environmental conditions should not be ignored.

Contemporary Group Ratios

A contemporary group ratio is calculated by dividing a calf's measurement (adjusted for age of dam, age of calf, etc.) by the average adjusted measurement of the group of same-sex calves with which it was raised, and multiplying by 100. This means an average calf in the group would have a contemporary group ratio of 100, calves with larger than average measurements would have values greater than 100, and calves with smaller measurements would have values less than 100. A weaning weight contemporary group ratio of 113 indicates the calf is 13% heavier than the average of the group with which it was raised. However, a contemporary group ratio of 113 on one farm may be entirely different from a contemporary group ratio of 113 on another. Therefore, contemporary group ratios should not be used to compare cattle from different locations or cattle raised under different conditions on the same farm. Contemporary group ratios are the best alternative when EPDs are unavailable but are not a reliable piece of information for making an informed genetic decision.

Expected Progeny Differences

The best way to determine breeding values for economically important traits is by using Expected Progeny Differences (EPDs). EPDs are computed using the bull's measurement along with measurements from any relatives. Additionally, EPDs account for differences in environmental (management) conditions. Therefore, EPDs are a predictor of the genetics that a bull will pass on to his offspring, which is what we are interested in when we are buying a bull. The difference in EPDs of two animals of the same breed indicates the expected differences in the average performance of the offspring of those animals. For example, if bull A has a weaning weight EPD of +60 pounds, and bull B has a weaning weight EPD of +40 pounds, and they are mated to a large number of comparable cows, under similar environmental conditions, a 20-pound difference between the average weaning weights of their calves would be expected (60 pounds - 40 pounds = 20 pounds). In other words, calves sired by bull A would weigh 20 pounds more at weaning on average than calves sired by bull B, due to genetics for increased growth to weaning. It is likely some calves sired by bull B would weigh more than some calves sired by bull A, but on average, calves sired by bull A would have a weight advantage. EPDs can be either positive or negative for the measurement in question. They are easily used to make comparisons among cattle but in most cases can only be used to compare animals of the same breed.

An additional use of EPDs is to get an indication of how a bull ranks within his breed. Charts are available from each breed that show how a bull ranks within the breed based on his EPDs. Having knowledge of how a breed performs on average and knowing how a bull's calves will perform can assist in matching a bull to your management and resources. In general, EPDs are a risk-management tool and are not a perfect science. If you use EPDs for selection purposes, you can purchase bulls that do not perform as expected, but this will happen far fewer times than if you use other means of selection for performance. It is important to use EPDs alone and not in conjunction with the bull's recorded measurements or ratios. By using EPDs in combination with other measurements, you actually reduce its effectiveness as a selection tool.

Traits available for comparison vary from breed to breed. They usually include some of the following: calving ease direct, calving ease maternal, birth weight, weaning weight, milking ability (expressed as pounds of weaned calf), yearling weight, and carcass traits (hot carcass weight, fat thickness, ribeye area, and marbling score). Other traits for which EPDs are offered on some breeds are yearling hip height, mature hip height, mature weight, scrotal circumference, stayability (measure of longevity), docility, and others. The following are descriptions and implications of selection of some commonly used EPDs (not all breeds provide all the EPDs listed).

Calving Ease or Calving Ease Direct EPD

The difference in two animals' calving ease EPDs indicates the average percentage difference in calving difficulty in first-calf heifers bred. In all breeds, larger numbers indicate greater calving ease.

Implications: This is the best EPD to use in trying to reduce calving difficulty. It is recommended this EPD *not* be used in conjunction with birth weight EPDs or the bull's actual birth weight because those factors have already been taken into consideration when calculating this EPD.

Calving Ease Maternal or Maternal Calving Ease

This EPD measures the calving ease of an animal's daughters. Larger values indicate a greater likelihood that an animal's daughters will have less calving difficulty.

Implications: High calving ease maternal EPDs on a bull does not indicate that he is an easy-calving (heifer-acceptable) bull; it means his daughters should be easy-calvers. To determine an easy-calving bull, use the calving ease direct, not calving ease maternal.

Birth Weight EPD

Differences in this EPD reflect differences in the average birth weight of the two animals' offspring.

Implications: Birth weight is genetically correlated to calving ease and growth in cattle. When a calving ease EPD is available then the birth weight is of no additional value, but if the breed does not have a calving ease EPD then the birth weight EPD can be used as an indicator trait. Bottom line, if a calving ease EPD is available, it is a better indicator of potential calving difficulty and should be used instead of the birth weight EPD.

Weaning Weight (Direct or Growth) EPD

This EPD measures the genetic contribution of the parent to weaning weight with no consideration to milk. In other words, differences in weaning weight direct EPDs indicate the average genetic potential differences of the calves to grow to 205 days, assuming milking ability of the dams is the same.

Implications: Weaning weight direct is genetically correlated with calving ease, mature weight and milking ability. As weaning weight direct goes up, calving ease usually goes down, mature size goes up, and milking ability usually decreases. However, yearling weight is usually increased.

Milk (Weaning Milk or Maternal Milk) EPD

The terminology for this trait is different among the breeds but refers to the expected milking ability of a parent's daughters in pounds of weaned calf. A bull with a 10-pound advantage in weaning weight milk EPD should produce daughters that raise calves that average 10 pounds heavier due to the increased milking ability of their daughters. Bulls with higher weaning weight milk EPDs sire daughters with an advantage in milking ability and/or maternal ability.

Implications: Milking ability is genetically correlated with growth traits. As milking ability goes up, the genetic potential for growth often goes down. Avoid extremes in this trait, particularly in breeds known for superior milking ability. It is easy to produce too much milk for the level of nutrition that is being provided. If this happens, cows lose condition, which results in increased feeding or loss of reproductive performance, either of which decreases the economic potential for the herd.

Weaning Weight Maternal (Combined or Total Maternal) EPD

This EPD is simply half the weaning weight direct EPD plus the weaning weight milk EPD. This measures the daughter's ability to raise a calf to weaning (205 days), regardless of whether the growth comes from genetics for growth or milk.

Implications: Most producers know whether they need to increase the milking ability or the growth potential of their herd and should focus on the point of need.

Yearling Weight

This EPD measures genetic differences in weight at 365 days. This EPD becomes more important than the weaning weight EPD when the marketing endpoint is postweaning.

Implications: Yearling weight is unfavorably correlated with calving ease and milking ability. Yearling weight is also highly correlated with mature weight. The mature size of your cow herd will increase and milking ability will likely decrease if you select for increased yearling weight and retain replacement heifers.

Fat Thickness EPD

This is a carcass trait EPD that indicates leanness. Lower values indicate less external fat cover, which reflects a more desirable yield grade.

Implications: Use extreme caution if you use this EPD when replacement heifers will be retained. A reduction in fat thickness, while beneficial to carcass value, can cause a reduction in fleshing ability and a loss of reproductive performance in replacement heifers if bulls with extremely low values are used.

Ribeye Area EPD

This is the best easily measured indicator of muscling. Ribeye area is a factor in calculating yield grades, with larger ribeyes contributing to a more desirable grade.

Implications: Extremes should be avoided in this trait. Even though larger ribeyes produce more desirable (lower) yield grades, there is a limit to how large of rib eyes we should be producing. Because cattle can be variable in muscle expression, this EPD should be used in combination with visual appraisal for muscling through the quarters.

Marbling Score EPD

This trait has the largest role in determining the quality grade of carcasses. Larger values indicate more marbling (flecks of fat within the lean of the ribeye), which results in higher USDA Quality grades (USDA Prime and Choice; see Chapter 9: The End Product). Each whole number difference reflects one marbling score difference. Therefore, an advantage of 0.5 marbling score EPD indicates progeny by that bull should grade 50 degrees better on average.

Implications: When marketing calves "on the rail," this trait can be important because quality grade is a large factor in carcass pricing. If a producer is not receiving a premium for high-quality carcasses, this trait should not be overemphasized.

Percent Intra-Muscular Fat (IMF) EPD

This measurement is similar to the marbling score EPD; however, it is determined using ultrasound data. This EPD should be used in the same manner as the marbling score EPD, with higher values indicating animals that should produce progeny that will have better USDA Quality grades.

Implications: Same as marbling score EPD.

Mature Weight and Height EPDs

This is an indicator of mature size of an animal's daughters. Mature weight is adjusted to a condition score 6 basis. In other words, differences in this EPD reflect the mature (five to 11 years) weight differences of daughters with a condition score of 6. The mature height EPD reflects the differences in inches of the animal's daughters at maturity.

Implications: Larger cows are typically less efficient in producing pounds of calf per acre than smaller, more moderate cows. This EPD allows producers to have direct control over the mature size of their cow herd. If these EPDs are not available, the best alternative is to select for moderation in yearling weight EPD because mature size and yearling weight are closely correlated.

Scrotal Circumference EPD

Differences in scrotal circumference are reflected in the average scrotal circumference of an animal's bull calf crop.

Implications: Breeders of seedstock can use this EPD to increase scrotal circumference of bulls they plan to market since scrotal circumference is an indicator of sperm production and serving capacity. For practical purposes, this EPD should be ignored by commercial producers, and emphasis should be placed on the bull's actual scrotal measurement. This is because an actual measurement of scrotal circumference is an indicator of that bull's serving capacity, and his scrotal circumference EPD is an indicator of how large his bull calves' scrotal circumference will be. In commercial operations, we are concerned with how many cows a bull can breed, but the bull calves will be castrated so the size of their testicles is irrelevant.

Heifer Pregnancy Rate EPD

Heifer pregnancy EPDs estimate differences in daughters' ability to conceive to calve as a two year old. Just like the stayability EPD, heifer pregnancy EPDs are expressed in terms of a percentage difference. For example, two heifer pregnancy EPDs, 5 and 10, differ by 5%. Daughters of the bull with the EPD of 10 are 5% more likely to conceive than daughters of the other bull, assuming both sets of daughters are raised and managed in the same environment.

Implications: Selecting bulls with higher heifer pregnancy EPDs should result in better pregnancy rates in the herd over time. However, because reproductive traits are lowly heritable, there is very little variation or spread between bulls for this EPD, and progress toward a noticeable change will take several generations of selection.

Stayability EPD

These EPDs are the prediction of the genetic differences between daughters' probability of staying in the herd to at least the age of six years.

Implications: Selecting bulls for higher stayability values should increase the longevity of his daughters that are selected as replacements. In other words, a bull with a higher value for stayability EPD should have a higher percentage of his daughters remaining in the herd to at least age six.

Docility EPD

These EPDs expressed as a difference in yearling cattle temperament, with a higher value indicating more favorable docility. Docility is not an indicator of the bull's behavior, which must be evaluated independently, but rather is an indicator of the potential behavior of his calves. It is still important to handle cattle properly to insure good disposition, regardless of their Docility EPD.

Implications: Selecting bulls for higher docility values should increase the calmness and behavior of his calves. However, it is important to remember that the cattle must still be treated calmly and gently to get the desired result.

Table 6-4. Example of performance information on various bulls.

	Calving Ease		Weaning Weight		Yearling Weight		Maternal Milk	
SIRE	EPD	ACC	EPD	ACC	EPD	ACC	EPD	ACC
A	6	0.70	+50	0.85	+90	0.80	+26	0.75
B	15	0.70	+30	0.90	+ 72	0.85	+30	0.80
C	3	0.70	+60	0.80	+110	0.75	+15	0.70

Accuracy Values

An accuracy value (ACC) is given for each EPD calculated and is a measure of the reliability of that EPD. EPDs are never perfect, and as more information is obtained on an animal, the EPD value may change, either up or down. Accuracy values indicate the likely maximum amount an EPD may change with new information. EPDs, regardless of their accuracy values, are the best available estimate of an animal's genetic merit.

Accuracy values range from 0.00 to 1.00. As accuracy increases, the amount of possible change in an EPD related to added information becomes smaller. These ranges of possible change are both trait- and breed-specific. For a correct range of possible changes in EPDs, obtain a sire summary for the breed in which you are interested.

Young bulls (which always have relatively low accuracy) are usually purchased, and any offspring produced are crossbred or non-registerable calves. Therefore, the bull's accuracy will likely remain low unless the bull has been genomically tested, which greatly improves his accuracy (see Molecular Technologies section later in this chapter). Even low accuracy EPDs are the best available indicator of a bull's progeny's potential performance.

Expected progeny differences are useful to both seedstock and commercial producers. Beef breeders can use records to mate the "best to the best," or, perhaps more important, cattle producers can use this information to select the right bull to use on a particular cow or set of cows based on their weaknesses or strengths. For example, a commercial producer selecting a bull to breed to first-calf heifers can use calving ease direct EPDs to choose a bull that will minimize calving problems, while maintaining an acceptable level of growth and milk. EPDs allow you to make genetic change or maintain current production that is appropriate for your production goals and environment.

It is helpful to understand how each economically important trait responds to selection based on performance information (EPDs). Table 6-2 summarizes these correlations.

Table 6-4 gives information on three bulls with different performance data. Assuming all bulls are structurally and reproductively sound and visually acceptable, which bull would you select? If your only priority is to maximize growth, select bull C. If your priority is calving ease (breeding heifers) and improving milk, select bull B. If your priority is improving growth and improving milk while maintaining calving ease, select bull A. Bull selection is an individual decision based on producer needs. The best bull for one producer may not be the best bull for another.

Economically Relevant Traits

Recent emphasis in genetic evaluations has been to determine economically relevant traits (ERT) for analysis. The purpose of this effort is to provide producers with EPDs that more closely reflect economic impact on their herd. A good example is the birth weight and calving ease direct EPDs. The birth weight EPD in itself has no economic impact to a producer because calves are not sold by the pound at birth. Instead, it is used as an indicator for calving ease, which has a major economic impact. Therefore, most breeds have developed EPDs for calving ease direct so that the actual trait of economic importance can be selected for. This does not mean that seedstock producers should stop collecting birth weights or other traits that do not have direct economic impact because these traits contribute information for computing the EPDs of the economically relevant traits.

Selection Indices

Selection indices have been available for beef producers for several decades but have not been widely used. In general, selection indices allow producers to make selection decisions for several traits simultaneously based on their economic relevance. In other words, an equation is developed, and each trait is weighted according to its economic impact. A bull's EPDs can be entered into the selection index equation, and a single number is generated based on that bull's ability to pass value to his offspring. For example, the following index might be used (this is only a sample index and should not be used in practice):

I = 3*CE + 2*CW + 3*MARB - 1*FAT

Traits	Bull A	Bull B	Bull C
CE	5.0	1.3	-2.5
CW	15	10	15
MARB	0.5	0.4	0
FAT	0.7	-0.3	-0.5

I = index value
CE = Calving-Ease Direct EPD
CW = Carcass Weight EPD
MARB = Marbling EPD
FAT = Fat Thickness EPD

The index values would be:

Bull A (I) = 3*(5.0) + 2*(15) + 10*(.5) - 3*(0.7) = 47.90
Bull B (I) = 3*(1.3) + 2*(10) + 10*(1.0) - 3*(-0.3) = 34.60
Bull C (I) = 3*(-2.5) + 2*(15) + 10*(0) - 3*(-0.5) = 24.00

With this example, Bull A would be the bull of choice because he was the highest indexing. This would indicate that Bull A would produce the most profitable calves based on this index. On average Bull A's calves will have $13.30 more value than Bull B's calves ($47.90 - $34.60 = $13.30) and $23.90 more value than Bull C's calves. One important thing to remember is that all indices do not fit all producers. In this example, the calves would be used in a terminal retained ownership program. For a producer who was breeding heifers and the calves were marketed at weaning, this index would have little value and could actually be detrimental. The other important aspect of indices is that the values should be weighted according to economic value, not hunches or guesses.

The problem with selection indices is that they are typically too general and do not perfectly fit an individual's operation. When a selection index is developed, certain assumptions have to be made that may or may not be correct for an individual operation. Additionally, when indicator traits are used rather than ERTs, there is more opportunity for error.

Currently there is not a good system available in the United States for developing indices that are custom made for individual producers. However, most breeds have developed generalized indices. Just as EPDs are not a perfect science, selection indices are not exact, and the opportunity for breeding mistakes still exist. However, they will allow beef producers to select bulls based on their total economic impact if the index matches their management and marketing plan.

Visual Appraisal

Many traits of importance, including body capacity, thickness, etc., are not measured by EPDs. Also, visual inspection is necessary to determine the structural soundness of a bull. Even with all the advanced technologies, visual appraisal is a necessary step of bull selection. The following traits are some that may be considered for visual appraisal.

Temperament

The excitability of cattle is of great concern to many producers. If having calm cattle that are easily handled is a selection priority of yours, then spend time locating a bull with a good disposition. Temperament is heritable, so parents with a good disposition usually have calves with a good disposition. Many breeds now offer Docility EPDs that will assist in selecting bulls that should pass good disposition to their offspring; higher values indicate better disposition.

Two types of disposition problems are cattle that try very hard to avoid human contact and cattle that try to make direct human contact. When evaluating bulls, you should move around the cattle, on foot, at a safe distance and in close proximity to shelter if needed. Cattle that try to avoid human contact are generally on the far side of the group with their head held very high. As you move around, they will always keep themselves positioned on the opposite side of the herd. They also appear nervous and make quick, excited movements. Aggressive bulls are usually easily identified as the bull on the front side of the group that is very excited; he always faces you and may challenge you when approached.

Temperament can cause problems because of increased health risk to humans, equipment damage and injuries to other livestock. Poor temperament has been shown to decrease cattle performance and it adversely affects carcass quality. Both types of disposition problems are very dangerous, and bulls exhibiting these behaviors should not be selected.

Body Capacity

Since cattle are foragers and usually deliver a 70- to 100-pound calf, adequate body capacity is needed for the animals to consume enough nutrients for maintenance and growth. Body capacity is determined by the length and depth of body and spring of rib.

Muscling

The bull should be well muscled, which is plainly evident in a large, bulging forearm and thickness in the round. Careful evaluation should be made to determine whether thickness is due to true muscling or fat deposits. Bulls with a wide base or stance that are rounded over the top-line and thick through the lower hindquarter (stifle region) are typically well conditioned and heavy muscled. Narrow-based bulls that are flat over the top-line yet show good thickness through the hindquarter are typically fat and may even be

light muscled. Location of muscling can be important. It is best if the bull has most of his muscling along the top-line and in the round. Since the most expensive cuts are toward the rear, heavy-fronted feeder calves are not desired.

Condition

Bulls should have adequate condition but should not be overfat. They should have a comparable body condition score of a 5 or 6.

Testicular Development

Testicles should be measured and be of acceptable size (see Chapter 5: Managing Reproduction, for more information on scrotal circumference). Additionally, they should be observed to determine if they are developed properly and if they are of similar size and have proper suspension. There will be slight variation in the size of the testicles of a bull, but large differences should be avoided.

Frame Size

If performance information is not available for frame size (or hip height), evaluate this trait visually. Remember, large frame bulls produce large frame calves, which are desirable as feeder calves, but will result in larger replacement females that can be more expensive to maintain.

Bull Selection Summary

If you are purchasing a bull in a sale, decide which bulls you like and how much you are willing to pay before the bidding starts. Do not sit back and see how they are going to sell and let the bull that is right for you get away. Do not make your selection decisions in the time it takes an auctioneer to sell a bull. Study the performance information ahead of time, and arrive at the sale site early enough to allow adequate time to evaluate the bulls. Any bull that does not appear "on paper" to be of potential benefit to your cow herd should be eliminated from further consideration, regardless of price or the appearance. Fads in the cattle industry are usually short-lived, and "bargain" bulls are often economic disasters in the end.

Sire selection continues after you purchase the bull. Observe the bull closely during the first few weeks of the breeding season to see if he is willing and able to mate with the cows. Bulls with a high libido (sex drive) and high fertility sire the early calves. Also, observe cows for return to heat after mating to see if they conceive. Your final step is to annually evaluate each bull's progeny. If the bull's calves are acceptable and the bull continues to pass a BSE, retain him. If the bull's calves are unacceptable, if the bull fails his BSE, or if a breed change is necessary to maintain heterosis, replace him.

Heifer Selection

Heifer selection is also important for commercial producers, but heifer selection is an easy task if proper sire selection is practiced. When replacement heifers are to be retained, bull selection cannot be overemphasized. Selection should include maternal ability, mature size moderation (particularly frame size), and calving-ease maternal, if available. From the resulting heifers, selection should be based on physical structure, body capacity, and likelihood of reaching puberty by the next breeding season (older heifers that are closer to their target weight are more likely to be ready to breed). Pelvic areas measurements can also be useful to cull heifers with undersized or misshaped pelvises (see Chapter 5: Managing Reproduction) If purchasing replacement heifers, knowledge of their sire or the reputation of the breeder is desirable.

Cow Culling

Cow culling plays a small role in the genetics of your herd and should be based solely on economic considerations. The following are likely reasons to cull cows: open, consistently poor calves or underperforming calves based on production records (young cattle—two- and three-year-olds—should not be expected to perform at the level of older cows), structural defects, or disease (see Chapter 7: Health and Management Techniques). Unusual situations in the market can alter normal culling procedures, but favorite cows that do not perform should not be kept.

Molecular Technologies

Biotechnologies have made many advances in recent years, and they are having a major impact on beef production. Most people are familiar with molecular biology used in criminal investigations that link hair, blood, or semen samples at a crime scene with a suspect. The basic principle is that every cell in an individual has the same genetic code as every other cell in that individual, and no two individuals have the exact same genetic code (with the exception of identical twins and clones).

Genomics and the corresponding Marker-Assisted or Genomic-Enhanced EPD, have become a reality. Within-breed genomic predictions based on over 50,000 markers (50K SNiP Chip) have proven to add accuracy to EPDs, particularly young bulls, for many traits. Tables 6-5 and 6-6 show the equivalence of information gained from a genomics test and the number of progeny that would be necessary to provide the same amount of genetic information on that animal from two different genetic evaluation sources. The push going forward will be the adoption of this technology by all breed associations and the development of methodology related to the use of this technology in crossbred and composite cattle. The benefit of this technology is increased EPD accuracy and the payoff to seedstock producers must come through commercial producers' willingness to pay for higher accuracy, which in turn means less risk. There is still a need to collect and routinely record phenotypic information by seedstock producers. Commercial producers need to realize that EPDs, and economic index values are the proper selection tools to be utilizing; molecular technology only makes these tools stronger, it should not replace them.

Genetic Defects Testing

In recent years several genetic defects have surfaced in several breeds. Because of molecular technologies the source of these defects have been identified and test developed to find carriers of the defective alleles. For more information on genetic defects in beef cattle, please go to https://ebeef.ucdavis.edu/ and search for "genetic defects."

Blood Typing or Parental Testing

Genomic information can provide a means of determining if an animal is from a specific mating or by a specific sire. For genetic evaluations to be correct, it is important that parentage is exact. In one-bull units, this is typically not a problem unless a bull jumps a fence. However,

in range breeding conditions, there are often multiple bulls in a pasture-mating situation. If correct parentage cannot be determined, the calf crop is excluded from the genetic evaluation, or if submitted incorrectly the EPDs computed will be less precise. This technology typically is not of importance to commercial producers but can have some usage for seedstock producers.

Homozygosity Testing

The genetics for color and horned/polled are very important for many beef producers. Knowing if a bull is homozygous or heterozygous for either of these traits can have economical value to a producer.

Most breeds, even those that are traditionally red, offer a black version. This was accomplished through a process called grading-up. For beef cattle, this generally occurred by breeding an Angus to the base breed, which will result in black calves, but they are half Angus. In turn, those calves were mated back to the base breed, which results in half of that generation being black; these calves are still 25 percent Angus. The black calves from that mating were then mated back to the base breed, and the black calves retained. This process is continued until the offspring are considered purebred for the base breed (usually seven-eighths or fifteen-sixteenths of the base breed). At that point, the black bulls and cows are mated to each other to generate black (about three-fourths of the first mating) and some red offspring. Of these black calves, and in subsequent generations, some will be homozygous for the black gene, and some will be heterozygous. A homozygous bull has two black genes and will always produce black calves. A heterozygous bull has one black and one red gene so, depending on the cattle he is mated to, he can produce either black or red calves. The same is true for breeds that have the horn gene; polled bulls may be carriers and produce horned calves.

Tests are now available that can determine if a bull is a red allele carrier or a horn allele carrier. Using the technologies described above, companies can determine from a blood or hair sample if a bull is a carrier. Each breed has specific guidelines for determining color and poll/horn genotypes, and producers should contact their respective breed association for details.

Table 6-5. Progeny equivalents for genotyped non-parent animals in IGS Multi-breed genetic evaluation.

Trait	Estimated Progeny Equivalent
Birth Weight	21
Weaning Weight	22
Yearling Weight	24
Calving Ease (Direct)	15
Maternal Calving Ease	3
Milk	18
Stayability	25
Carcass Weight	6
Rib Eye Area	8
Marbling	6
Backfat	8

Provided by Mahdi Saatchi, Lead Genomicist, International Genetic Solutions (IGS). 2019

Table 6-6. Progeny equivalents for genotyped non-parent animals in Angus genetic evaluation.

Trait	Estimated Progeny Equivalent
Birth Weight	21
Weaning Weight	26
Yearling Weight	21
Calving Ease Direct	28
Milk	33
Scrotal Circumference	13
Carcass Weight	9
Rib Eye Area	12
Marbling	9
Backfat	10

Provided by Steve Miller, Genetic Research Director, Angus Genetics Inc. (AGI). 2019

Before incurring the cost of homozygosity testing, use common sense. If you examine the pedigree of an animal and either parent is homozygous recessive for that trait, you know the animal is a carrier (heterozygote). Remember that a calf gets one color gene from each parent, so if one parent has two red genes, one of those red genes is passed to that calf. If both parents are black and the calf is black, there is no way of determining homozygosity/heterozygosity other than testing. The same is true for polled/horned cattle.

Summary

In summary, there are two important practices that commercial producers should apply to their beef breeding program: crossbreeding and selection. Breeds should be selected based on their ability to achieve your production/economic goals and their ability to fit your production environment (management). These breeds should be used in a planned crossbreeding program that maintains a high level of heterosis. Once the breeds are determined, individual bulls should be selected based on the level of performance you desire for each trait of economic importance. Overall performance of the breed for these traits should be considered in determining this level. Bulls should also be appraised visually and be sound breeders.

If these steps are followed, you can customize your cow herd to meet your goals within your production environment.

Genetics Glossary

Alleles—The possible forms of genes (i.e. poll and horn alleles) at a locus. Because genes occur in pairs, one gene of a pair may have one allele and the other gene of that same pair may have a different allele.

Carrier—An animal that has two different alleles to make up its pair of genes, both the poll and horn alleles (Pp). The dominant allele (poll) masks the existence of the recessive allele (horn) so it is polled, but it carries the horn allele and can pass it on to its calves.

Dominant—Masks the characteristic of the recessive allele. Characteristic is expressed in full if either homozygous or heterozygous (i.e. poll is dominant to horn).

Double polled—Refers to mating a polled bull to a polled cow, and producing a polled calf. It is incorrect to assume that this calf is homozygous polled; one or both parents could be carriers, and if only one horn allele gets passed to the calf it will be a carrier.

Expected Progeny Difference (EPD)—Best selection tool available to evaluate a bull's genetic merit.

Gene—A gene is a specific section of DNA on a chromosome that serves a biological function. Two copies of each gene exist in an animal. Only one gene of each pair is randomly transmitted to the

offspring; the offspring gets one gene from each parent, thus giving it a pair.

Genotype—The genetic makeup of the animal.

Heterosis—Advantage of crossbreeding that results in the offspring performing better than the average of the parents that produced it.

Heterozygous—The gene pair has different alleles.

Homozygous—The gene pair are matching alleles.

Horned—The presence of horns that are attached to the skull.

Inheritance mode—The passing of genes from parents to offspring and how they are expressed.

Locus—Location on the chromosome where a specific gene resides.

Phenotype—The physical appearance of the cattle. For the purposes of this article there are three possibilities: smooth polled, scurred, or horned.

Polled—Absence of horns (can be scurred).

Recessive—Is completely masked if paired with a dominant allele. Is only expressed if homozygous (both alleles are recessive).

Scurs—Horn-like tissue that is attached to the skin rather than the skull. Can vary in size from small growths to small horn-like structures.

Seedstock—Broadly refers to animals that are saved for breeding purposes. A seedstock producer typically refers to a producer that sells bulls to other seedstock producers or commercial producers. These bulls are often purebred, but can be composite or crossbred bulls.

Smooth polled—Absence of both horns and scurs.

SNiP—Single Nucleotide Polymorphism. This is the location where there are differences in the population at a single base pair. This difference may or may not have an effect on the animal.

Trait—Anything that can be measured or observed related to cattle. Weaning weight and coat color are examples of traits.

Health and Management Techniques

Michelle Arnold, Roy Burris, and Lee Townsend

A healthy, disease-free herd is a goal for all beef producers. A herd health program will be most successful when it is customized to meet the herd's needs. Local veterinarians are knowledgeable about diseases in the area and should be able to make cost-effective recommendations. Plan a program that prevents diseases and disorders; do not depend on a veterinarian just to treat problems.

Requirements for a successful herd health program include:

- Adequate handling facilities
- Good nutrition, especially with trace mineral supplementation
- A working relationship between producer and veterinarian (valid veterinary-client-patient relationship)
- A willingness to follow a program once it is established
- A management level that reduces stress in cattle

Several management techniques including identifying, implanting, vaccinating, castrating, and dehorning, should be done in as timely and humanely a manner as possible. Having a controlled breeding season simplifies timing of vaccines. As discussed in Chapter 4, adequate handling facilities are necessary to properly restrain the animals for vaccination and treatment. Work carefully when processing cattle. If trying to set a record for speed, cattle may be unduly stressed or injured. Cattle can be worked rapidly enough when they are handled skillfully and gently and when the handling facility is constructed so that cattle flow through it easily. Remember that animal health products, such as vaccines and implants, must be administered properly to be effective. Therefore, emphasize proper technique rather than speed. Vaccines do not work in animals that are chronically diseased, in poor nutritional status, stressed, ill, or heavily parasitized.

Pre-calving Check

Spring calving cows, particularly heifers, in poor body condition are at risk for calving problems. The result may be lighter, weaker calves at birth, which can lead to a higher death loss, and more susceptibility to diseases such as scours. Pregnant animals in poor condition before calving provide inferior colostrum and have lower milk production. This can lead to lighter weaning weights or fewer pounds of calf to sell. Females in less than desirable body condition at calving are slower to return to estrus. Therefore, body condition at calving affects the current calf crop (milk production) and next year's calving date (due to a later rebreeding date).

Spring calving herds will also require a high magnesium supplement to prevent grass tetany or "hypomagnesemia" (see "Forage-related Disorders" later in this chapter for specific information on magnesium requirements).

Environment has an impact on calf survival. Calves born into a filthy environment (muddy lot) have the energy drained from them quickly if cold and wet and bacteria can easily invade the navel. A calf has little stored energy reserves and needs this energy to stand and nurse shortly after birth. A clean, dry pasture for calving is ideal if there is shelter and a catch pen so the cow can be restrained if calving assistance is required. Research has shown that when cattle are fed in the early evening (5 p.m.to 6 p.m.) during the last few weeks of pregnancy, more cows will calve during daylight hours, making calving problems easier to identify.

Calving Difficulty

Observe heifers and cows for signs of calving difficulty. Allow a reasonable amount of time for a cow to deliver on her own, approximately two hours from appearance of the water bag to delivery of the calf. Intervention is necessary if either the water bag or feet have been visible for more than one hour with little or no progress or if actively straining for more than 30 minutes without making visible movement of the calf. Heifers should be allowed no more than one hour to deliver the calf once the water bag is visible before intervening. Calving difficulty often occurs in mature cows when calves present backwards (dewclaws are pointed up), breech (tail first and no legs), or malpositioned legs or head. If the heifer/cow is not making progress, she should be quietly moved to a facility to adequately restrain her for examination. Clean the area around the vulva with soap and water. Use plastic obstetrical sleeves; bare hands and arms are not recommended in case potentially contagious organisms are present. Plenty of lubrication should be used to protect the vaginal area. A calf can generally be delivered with firm, steady traction if the head and both forelimbs are in the birth canal. If the calf is too large, the head and legs will not be able to enter the birth canal and a Caesarean section must be considered. Prolonged efforts with no progress can lead to a dead calf and cow. If you cannot correct a problem after 30 minutes of trying, you should call for veterinary assistance to assess the situation. Bear in mind that cows assisted early (within 90 minutes) have a 16% higher pregnancy rate at pregnancy check but every hour a cow spends stuck in Stage 2 labor delays rebreeding by four days.

During gestation, the placenta of the cow effectively separates the blood of the fetus from that of the dam and prevents any transfer of protective immunity while in the uterus. Therefore, the calf is born completely dependent on the absorption of maternal antibodies from colostrum after birth. Colostrum is the milk produced from the mammary gland in the first 24 hours after birth. A calf's gastrointestinal tract is designed to temporarily allow the absorption of antibodies (immunoglobulins) from the small intestine, called "passive transfer." Passive transfer only occurs during the first 24 hours after birth; it is most efficient in the first four hours of life and declines rapidly after 12 hours of age. At 24 hours, the gut is completely closed and there is no further immunoglobulin absorption. These absorbed antibodies must be consumed in order to protect the calf from disease-causing organisms

until its own immune system becomes functional. Early suckling of good quality colostrum is essential for survival.

The inability of the calf to get adequate colostrum after birth can lead to "failure of passive transfer" (FPT). If the calf is weak at birth, especially if it has a swollen head, or was manually delivered from a heifer, an oral calf feeder can be used to provide the necessary colostrum to the calf. The oral calf feeder (esophageal feeder) should be used on a calf positioned with the head bent down at a slight angle (nose below the ears), the ball should be lubricated (vegetable oil), and you should see or feel the ball on the left side of the neck when properly positioned (Complete instructions may be found in the section on calf scours). Colostrum from your farm is the best one to use because it has antibodies against the diseases found on the farm however good powdered colostrum replacement products are commercially available.

A mature cow has more concentrated antibodies (immunoglobulins) in colostrum than a heifer; the concentration of immunoglobulins is highest immediately after calving and decreases over time. Colostrum can be frozen and kept until the next calving period but no longer than one year. Be careful to freeze it in small amounts and not in one large gallon jug. Frozen colostrum must be slowly thawed out in a warm water bath and not placed in the microwave to thaw. Be cautious about using another farm's colostrum, especially from a dairy, because of the risk of acquiring Johne's disease and bovine leukosis virus.

Numerous colostrum replacements are available on the market. The use of a colostrum replacement product offers a convenient method to improve passive immunity by mixing a powdered commercial product containing bovine IgG with water and feeding the calf. A colostrum replacer contains a minimum of 100g of IgG per dose, protein, minerals, vitamins, and energy and is designed to be fed when no maternal colostrum is available. This should not be confused with a colostrum supplement product that is designed to be fed *in addition to* and after natural colostrum. Colostrum supplements are significantly less expensive than replacement products because they contain less than 50 mg IgG per dose and have no added nutritional value.

Annual Cow Evaluation

A cow should be evaluated every year to determine if she can continue in the herd. Seven quality checks are designed to determine her potential for reproductive success and detect any physical conditions that might cause future problems. Pregnancy check is an ideal time to evaluate these seven areas.

1. **Pregnancy.** If not pregnant, cull at appropriate time to reduce feed costs.
2. **Disposition.** Flighty cows that are difficult to move into working pens and chutes often produce calves with the same traits. Culling troublesome cows will select for good disposition in the herd.
3. **Eyes.** Check for "cancer eye."
4. **Feet and legs.** Check for lameness or poor conformation.
5. **Udder.** Check for dry or light quarters, poor conformation and large, pendulous teats that make nursing difficult.
6. **Body condition score (BCS):** This should be between 5 and 6 in an adult cow.
7. **Mouth:** Check if older cow or low BCS for teeth problem; "smooth-mouthed" or "broken-mouthed" will require feed supplementation to maintain body weight.

Deciding Who to Cull

Every year, the cow-calf producer needs to critically evaluate each animal in the herd and decide if she is paying her upkeep. Open cows (those that are not pregnant) at the end of breeding season obviously are the top of the cull list. With variable costs running $400-$500 per year per head, breeding stock depreciation running another $100-$150 per year, and an additional $100-$300 in fixed costs (2017 estimates), keeping open cows is a financial black hole. Beyond pregnancy status, what other variables are important to evaluate? Structural soundness, body condition score, age, performance, and disposition are vital components in developing a culling order. This culling order is exceptionally important during times of drought or a year with marginal hay production because deeper culling may be required to manage through a difficult season. To begin, it is best to think about those cattle in the herd with the least chance of being productive in the long term or farthest away from being productive. Equally important are factors such as disposition and phenotype that affect the marketability of offspring. The following is a list of factors to consider when deciding who to cull this year.

Example of a Culling Order
- Disposition
- Pregnancy status
- Structurally unsound/chronic condition
- Age
- Poor performance
- Phenotype
- Bred cows over 9 years of age
- Replacement heifers
- Bred cows 3-9 years of age

Disposition. A cow's attitude is an important consideration in any cattle operation. Bad behavior has both a genetic component and is also learned by calves at an early age. Mean cattle are dangerous to people, damage facilities, tear up fences and make gathering and working cattle a nightmare. Remember a good cow can be protective without being dangerous and destructive.

Pregnancy Status. A cow should produce a calf at least once a year and the sale of that calf needs to pay her way. Diagnosing a cow as "open" (not pregnant) is as simple as a veterinarian palpating for pregnancy at least 40 days after breeding or removing the bull. A simple, inexpensive blood test can also be used 28 days post-breeding to determine pregnancy status. If many cows are found open at pregnancy check, work with a veterinarian to determine if reproductive disease, poor nutrition, bull infertility or inability was the cause. Remember that cows that calve late in the season have less opportunity to breed back in a controlled (for example, 90 day) breeding season. Summer heat and fescue toxicosis can be important contributors to low conception rates.

Structural soundness/chronic conditions. Bad hooves or claws, lameness due to hip/knee injury, eye problems, and poor udder conformation are all examples of structural problems that adversely affect performance (Figure 7-1). Good feet and legs are essential for weight maintenance, breeding, calving, self-defense, and raising a calf. The udder should be firmly attached

with a level floor and high enough that newborn calves can easily find and latch onto teats. Cows with blind or light quarters, funnel or balloon shaped teats, or any history of mastitis are strong candidates for culling.

Cows with chronic conditions that will not improve such as progressive weight loss, early cases of cancer eye, repeated episodes of vaginal prolapse during pregnancy, and extreme sensitivity to the effects of fescue toxicosis should be removed from the herd as soon as the calf is weaned. Cows with confirmed disease conditions such as Johne's disease, bovine lymphoma, or advanced cancer eye should not be returned to a commercial market as breeding stock. The most common reasons for carcass condemnation at slaughter include emaciation, lymphoma, peritonitis, cancer eye, blood poisoning, bruising, and other cancers.

Age. Cows are considered most productive between 4-9 years of age. Look at the teeth to assess the age but evaluate them in light of diet-cows that eat gritty or sandy feeds and forages have increased tooth wear beyond their years (see "Estimating Age of Cattle by Their Teeth" later in this section). Cows with badly worn or missing teeth will have a hard time maintaining body condition. Older cattle die of natural causes, too.

Poor Performance. Record keeping is an invaluable tool for evaluating performance. Readable visual tags on both the cow and calf allow matching of calf sale weights to the dams and identification of cows that did not produce a calf. Inferior genetics and poor milk production produce lightweight calves that do no grow well. An overweight cow or large framed cow with a small calf that doesn't grow and gain weight usually means the cow is not producing much milk. Sick baby calves may be an indication of poor quality colostrum and poor mothering ability.

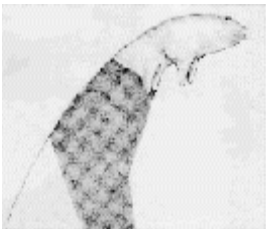
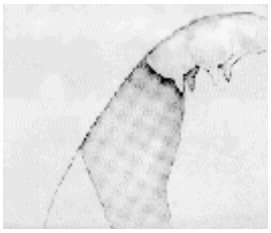
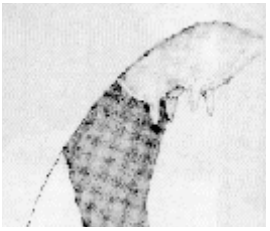
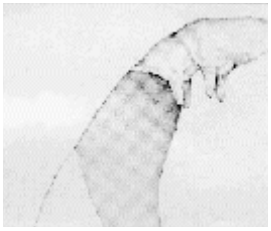
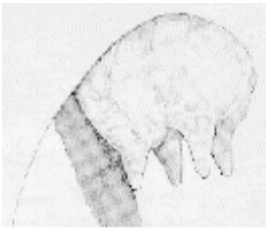
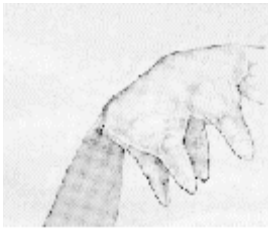
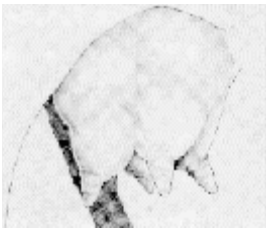
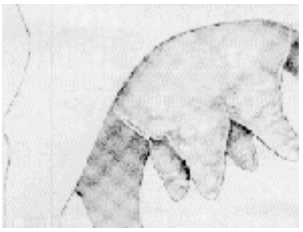
Phenotype. These are cows that do not "fit" the herd because of external features such as unusual breed, size, muscling and color. These challenges may be overcome to some degree by choice of sire to balance out the unwanted traits. Remember that buyers of commercial calves look for uniformity in color, weight, and frame in a set of calves.

The last ones to go. Hopefully culling will never have to go this deep in the herd. Bred cows over 9 years old, replacement heifers (especially those that did not breed in the first 30 days), and bred cows 3-9 years old should be the last sold. Thin cows that conceive late in the breeding season should go first.

Since 20% of gross receipts in a typical cow-calf operation come from the sale of cull animals, pay attention to price seasonality and body condition score before sending these animals to market. Prices are highest in spring and lowest in late fall/early winter when spring born calves are weaned and culls sent to market. Adding weight and body condition to culls is an opportunity to increase profitability but can be expensive. Work with a nutritionist to come up with realistic cost projections before feeding cull cattle for a long period of time.

When it comes to making decisions on who to cull, remember to consider functionality in the environment. Is she an "easy keeper?" Does she keep flesh and condition and raise a good calf, even when feed and forage is limited? On the opposite side, does she give too much milk or is her frame size so large that you can't keep weight on her, even when pasture is plentiful? Is her pelvis so small and

Figure 7-1. Udder scoring system for beef cattle.

Score	Description	
	Udder Suspension	**Teat Size**
9	Very tight	Very small
		
7	Tight	Small
		
5	Intermediate	Intermediate
		
3	Pendulous	Large
		
1	Very pendulous	Very large, misshapen
		

American Hereford Association; BIF Guidelines, 2020

Cull Cow Language

- Breakers (75-80% lean): Highest conditioned cull cows (BCS ≥ 7), excellent dressing percentages
- Boners or "boning utility" (80-85% lean): Moderately conditioned (BCS 5-7), well-nourished commercial beef cows (usually highest price cull)
- Leans (85-90%): Lower BCS (1-4), lower dressing percentages, susceptible to bruising during transport and expect more trim loss. Moving cows from lean to boner status can usually be done efficiently

tight that calving is a problem and will be a problem in her offspring? Functionality leads to longevity and improved efficiency. By retaining more young cows in the herd, you can decrease the number of replacement heifers needed and cull cows that are only marginally profitable. Young cows also increase in value as they mature because the body weight of the cow and her calf's weaning weight will continue to increase from 2-5 years of age. Longevity may also be improved through crossbreeding because hybrid vigor adds essentially 1.3 years of productivity or one more calf per cow.

In summary, a herd of easy-keeping, efficient cows is possible through rigorous culling and careful selection of replacements. Matching genetics to management and environment results in maximum efficiency, longevity, and, ultimately, maximum enjoyment of cattle production.

Table 7-1. Sample cattle working schedule.

Time	Calves	Cows/Bull
Birth	• Identify • Record birth date, dam • Castrate (delay 12-24 hours for bonding with dam)	
Prebreeding	• Vaccinate 7-way clostridial (Blackleg) • Pinkeye vaccine in the spring • Castrate/dehorn if needed • Implant male feeder calves if castrated	• Vaccinate IBR/PI-3/BVD/BRSV, Lepto-5, Vibrio, Pinkeye • Deworm • Sort into breeding groups • Bull breeding soundness exam
Midsummer[1]	• Deworm[2] • Reimplant steers according to label directions	• Deworm[2] • Remove bull from spring breeding herd
Preweaning	• Vaccinate: IBR/PI-3/BVD/BRSV • Booster 7-way clostridial vaccine	• Pregnancy examination • Evaluate cows for problems
Weaning (after stress is over)	• Booster IBR/PI-3/BVD/BRSV • Treat for internal and external parasites	• Sell open and cull cows • Treat for lice and grubs in late fall
Before calving		• Vaccinate against scours

[1] Avoid working cattle during periods of extreme heat; early morning is best.
[2] Use a dewormer that is effective against inhibited Ostertagia larvae.

Vaccinations

Your veterinarian can provide valuable advice to develop a vaccination program to prevent contagious diseases for your particular herd. The time of year you calve and when you prefer to work them will influence the program for your herd. Table 7-1 is an example of a Cattle Working Schedule, in which cattle are gathered five times a year.

Vaccination is a tool that is used alongside other management tools such as forage management, proper nutrition, maintaining a clean environment, biosecurity, and stress management. Vaccination programs are designed to protect the herd against disease caused by infectious organisms, such as viruses or bacteria. Vaccines contain either killed or modified live organisms that do not cause disease. These vaccine organisms stimulate the animal's immune system to "remember" how to mount a response if it is later infected with that organism. A vaccine cannot prevent infection but will allow the animal to recognize and respond more quickly to infection, lessening the severity of disease.

Most vaccines contain either modified-live or killed organisms or a combination of the two. Modified-live vaccines (MLV), both for viruses and bacteria, replicate (multiply) in the animal after injection. The organisms have been modified so that they do not cause the disease but stimulate the immune system similar to a natural infection. In general, MLV stimulate a longer-lasting immunity than killed vaccines. However, MLV may cause abortion if given improperly to pregnant cattle. Most modified-live vaccines must be reconstituted by adding sterile water (diluent) to a dehydrated "cake" in a separate sterile vial. Once mixed, the vaccine organisms are fragile and survive for only 45 minutes if in direct sunlight and/or heat. Use a cooler to protect vaccines from extremes of cold or heat and from sunlight. In a cooler, MLV organisms can survive approximately one to two hours.

Killed vaccines contain organisms or subunits of organisms that do not replicate (reproduce) in the animal after injection. Killed vaccines contain an adjuvant (added substance) that stimulates the immune system to respond to the vaccine challenge. Table 7-2 lists the advantages and disadvantages of killed and modified-live vaccines.

Table 7-2. Modified-live versus killed vaccines.

	Advantages	Disadvantages
Modified-live vaccine	• Single dose can provide protection • Less expensive per dose • More rapid immune response • More natural and complete immune response • Longer-lasting protection	• May cause abortion in pregnant animals • Need to be reconstituted before use • Inactivated by heat and sunlight • Partial bottles cannot be stored • Must be used within 1-2 hours after mixing
Killed (inactivated) vaccine	• Can safely be given to any animal at any stage of pregnancy • Stable in handling and storage	• Increased adverse reactions • More expensive • Needs 2 doses initially to be protective • Shorter protection time

Vaccines are available for many disease conditions. However, many diseases do not routinely threaten most beef herds, and some vaccines are not sufficiently effective to justify their use. Therefore, only the most significant vaccines are included in a routine vaccination schedule. In the young animal being vaccinated for the first time, a second or "booster" vaccination is often required a few weeks after the first vaccination to properly prime the immune system. This is exceptionally important if using killed vaccine. Label directions must be followed to obtain the desired immune response.

Vaccinations for the Cow-Calf Operation

One of the most common questions in cow/calf production is what vaccines are necessary on an annual basis in Kentucky to keep the herd healthy. The guidelines set forth here are designed to help answer that question but the details of what products to use and when to administer them are best decided by the producer and veterinarian. Technology is constantly changing and updating science to make today's vaccines safer and more effective than any time in the history of cattle production. However, the sheer number and types of vaccines and dewormers available today can make the correct selection of products challenging. Every farm has different disease risks and challenges regarding labor and facilities needed to work the cattle. A veterinarian is equipped with the knowledge and skills to determine what will work best in each unique situation.

Cows and Bulls 4-6 Weeks Prior to Breeding

- Viral respiratory vaccine (IBR, BVD, PI_3, BRSV) with *Campylobacter fetus* (vibriosis) and 5-way leptospirosis (HB optional) Fetal Protection (FP) product preferred. If the cow is pregnant at the time of vaccination, use a killed vaccine product to reduce the risk of accidental abortion. Certain modified live vaccines can be used in pregnant animals, but only if used strictly according to label directions.
- Seven-way clostridial vaccine (Blackleg), necessary if under 2 years of age; optional (highly recommended) as the cow ages depending on the exposure risk of the herd
- Deworm—perform at least twice per year (spring and fall). If only once is possible, deworm in late spring. Deworming in the fall is a good practice to reduce the number of worms that overwinter in the cow but is not as important as the spring and early summer when larvae are active in rapidly growing pasture. Do not deworm adult cattle if less than 2 weeks prior to breeding season as it may interfere with hormone production.
- Tag cattle for identification and/or retag those that have lost tags.
- Breeding Soundness Exams are highly recommended for herd bulls and should be conducted 60-75 days prior to turnout (see Chapter 5, "Managing Reproduction"). Bulls need the same vaccinations and deworming as the cow herd.

Heifers 6 Weeks Prior to Breeding

- Viral respiratory vaccine (IBR, BVD, PI_3, BRSV) with *Campylobacter fetus* (vibriosis) and 5-way leptospirosis—modified live strongly recommended; fetal protection (FP) product is preferred; follow label directions; booster at minimum 30 days prior to breeding
- Seven-way clostridial vaccine (Blackleg)
- Deworm with a branded (not generic) product; heifer is under increased nutritional demand because she is still growing herself and trying to reproduce; young animals do not have the immunity to parasites that adult cattle possess, therefore it is important to use effective dewormers

Calves 1-3 Months of Age

- Identify with tag
- Vaccinate with 7-way clostridial (Blackleg) vaccine—although the calves are too young to mount a good immune response, this dose of vaccine will initiate ("jump start") the immune process; do not give Blackleg vaccine at birth.
- Dehorn, castrate—the earlier these practices are completed, the better
- Optional Practices:
  - » Implant steers at the time of castration (unless you plan to sell calves in an organic or natural market)
  - » Viral respiratory vaccine-killed, MLV (see "Additional Considerations," page 99), or intranasal (intranasal preferred for young animals<4 months old)
  - » Pinkeye vaccine (administer in late spring/summer prior to fly season)
  - » Deworm; begin deworming calves at 4-8 weeks old depending on time of year and expected level of pasture contamination with parasite larvae
  - » Test for BVD-PI (ear notch); consult a veterinarian if this is something to consider; if BVD has been diagnosed in the herd or there is a history of unexplained abortions, stillbirths, weak calves or birth defects in the herd, testing all calves is the proven first step to find persistently infected (PI) animals

Calves 2-3 Weeks Pre-weaning

- Viral respiratory vaccine (IBR, BVD, PI_3, BRSV)-killed or MLV (see "Additional Considerations," page 99), but follow label directions regarding MLV usage in nursing calves
- Deworm with an endectocide (examples: Ivomec®, Dectomax®, Eprinex®, Cydectin®, LongRange®) for internal and external parasites; use a branded product—not a generic; drench anthelmintic (white liquid dewormer given by mouth) such as Safeguard®, Synanthic®, or Valbazen® may be used but a second product will be required for external parasite (flies, lice) control
- 7-way clostridial vaccine (Blackleg); follow label directions regarding the need for a booster
- **Optional:** Vaccinate with *Mannheimia haemolytica* toxoid—this vaccine, commonly known as a "Pasteurella shot" or "Pneumonia shot" is given pre-weaning in anticipation of the stress associated with weaning; in a low-risk situation in which the calves are weaned on the farm and no new additions are added to the group, this vaccine may be delayed until after weaning; consult your veterinarian and check your marketing plan since many programs (for example: CPH45) specify what vaccines must be administered and when in order to participate.

Calves at Weaning

Delay working calves until the stress of weaning is over. It is best to wait until the calves are eating, drinking, and most (if not all) have stopped walking and bawling.

- Booster+ viral respiratory vaccine-MLV strongly recommended and often required by special sales.
  - » For replacement heifers and bulls: Viral respiratory with *Campylobacter fetus* (vibriosis) and 5-way leptospirosis vaccine included. Booster according to label directions; MLV is strongly recommended for recently weaned calves to be kept in the herd.
  - » For steers: Viral respiratory **without** *Campylobacter fetus* (vibriosis) and 5-way Leptospirosis vaccine.

- Booster 7-way clostridial *if required* by label direction
- Optional practices:
  - » Implant: Follow label directions, especially when re-implanting. Do not implant females to be used for breeding purposes. Do not implant if planning to sell on the natural or organic markets.
  - » *Pasteurella multocida* and/or *Histophilus somni* (formerly known as *Haemophilus somnus*) vaccines—consult with a veterinarian for current recommendations.

Cows after Calves are Weaned

- Check cows for pregnancy by palpation, ultrasound, or blood test. If open, strongly consider culling her.
- Check for other problems: Eyes, mouth, udder, feet and legs, body condition, disposition.
- Scours vaccine—administer prior to calving. Products vary on when to administer them during late gestation so follow label directions carefully.
- If leptospirosis is a persistent problem, cows may need a booster of 5-way leptospirosis vaccine.

Additional Considerations:

- If calves cannot be processed preweaning, then do the steps for "Calves at Weaning" then booster the viral respiratory vaccine (and the 7-way clostridial if required on label) in 2-3 weeks. If castrations and dehorning were not done earlier while the calf was on the cow, these practices need to be completed as soon as possible. Tetanus vaccination is strongly recommended when performing late castration; especially if banding. Consult your veterinarian regarding whether to use a tetanus toxoid or antitoxin.
- Modified live vaccines (MLV) provide fast, broad immunity and are excellent stimulators of cell-mediated immunity. They are generally preferred in recently weaned calves and usually required by most preconditioned sales. However, **only use modified live vaccines in pregnant cows and in nursing calves if the cows were vaccinated with MLV in the last 12 months** (check label for specific requirements). If this requirement is not met, a killed vaccine must be used until the cow is open and the calf is weaned.
- Killed vaccines provide safe, protective immunity but must be given twice (usually 2-3 weeks apart) if it is the first time a viral respiratory vaccine is administered. Annual boosters are required after the initial two-shot sequence; twice a year is recommended when using killed products.
- If heifers have been allowed to stay with the herd bull until weaning, most likely some are pregnant. A prostaglandin injection (for example: Lutalyse®) can be given to the heifers once they have been away from the bull a minimum of 10 days. These injections work best in early pregnancy so do not delay administration if needed.
- Try to minimize the number of injections given at one time as much as possible. Multiple vaccinations cause neck soreness. Multiple Gram negative vaccines may cause cattle to spike a fever and go off feed for a short period of time.
- Keep good vaccination records. Record date, vaccine name, serial numbers and expiration dates at a minimum.
- Utilize fly control and pinkeye vaccine beginning in late spring.
- Letters in a vaccine name mean:
  - » IBR, BVD, BRSV, and PI_3 are diseases included in a viral respiratory vaccine.
  - » An "FP" in the vaccine name stands for "fetal protection" and means protection against fetal infection and abortion due to the BVD virus.
  - » An "HB" in the vaccine name stands for the strain of *Leptospira* known as "Hardjo bovis" that is a common cause of reproductive failure in cattle.
  - » "HS" stands for "*Histophilus somni*" (formerly known as *Hemophilus somnus*).
  - » "L_5" stands for the five strains of leptospirosis.
  - » "V" stands for "vibriosis."

In summary, vaccination programs must be designed around the specific needs of the cattle. Numerous vaccines are available for other diseases (for example: brucellosis, anaplasmosis, trichomoniasis, *Clostridium perfringens* Type A, foot rot, papilloma or wart virus) but they may or may not be useful in all situations. Always discuss concerns with a veterinarian to develop the plan that will work the best.

Diseases

Several diseases can be a problem in Kentucky beef herds. By understanding the causes of these diseases, producers can be better equipped to prevent them.

Anaplasmosis

Anaplasmosis is caused by a microscopic parasite that destroys red blood cells. Horseflies, mosquitoes, and ticks are the principal blood-sucking insects that spread anaplasmosis. Since the infection is easily transmitted by the transfer of infected blood, outbreaks can occur after working cattle without proper disinfection during procedures such as dehorning, castrating, ear tagging, and vaccination without changing the needle. Disinfect equipment and change needles between animals to minimize spread of the disease.

Initial signs of anaplasmosis include fever, weakness, icterus (jaundice), anemia, pale mucous membranes, dehydration, and constipation. Often no signs are observed and the animal is simply found dead. Most cases occur in late September, October, and early November in adult cattle (usually three years old and up).

Oxytetracycline is the drug of choice for treating anaplasmosis. In an outbreak situation, mass medication of cattle with a single injection of long acting oxytetracycline will likely arrest any clinical or late prepatent infections. Oral consumption of chlortetracycline for at least 60 *continuous days* at the higher level of the approved range 0.5-2 mg per pound of body weight during the insect vector season (May-November) has been demonstrated to control active infection. Currently, no commercial vaccines are available against anaplasmosis although Kentucky is approved by the USDA for sales of the experimental anaplasmosis vaccine marketed by University Products LLC of Baton Rouge, La. The vaccine has provided good protection against anaplasmosis throughout the United States, including Puerto Rico. The vaccine recommendations include a two-dose regimen given four weeks apart with annual revaccination required.

Blackleg

"Blackleg" and "malignant edema" are diseases caused by clostridial organisms that live in the ground in a protected spore form and enter calves through ingestion, inhalation or wounds. The bacteria are not spread directly from animal to animal but come from the soil. These organisms produce toxins (poisons) in the animal's body that are rapidly fatal. Blackleg usually occurs in cattle six months to two years of age; malignant edema can occur at an older age.

The "7-way" or "8-way" clostridial vaccine is effective, inexpensive, and economical. All calves should be vaccinated beginning at two to four months of age, depending on the product. Follow label directions carefully regarding what age to administer the primary and booster doses of the vaccine.

Bovine Leukosis Virus

Bovine leukosis virus (BLV) is a very common occurrence in beef cattle herds. The virus is usually transmitted through contact with blood from an infected animal. BLV can spread through such procedures as injections with dirty needles, surgical castration and/or dehorning, tattooing, rectal palpation as well as through biting insect vectors such as horseflies. Calves may also be exposed while nursing an infected dam. BLV is the cause of the cancerous blood disease "enzootic bovine leukemia" (bovine lymphosarcoma or malignant lymphoma). However, only approximately 2% of BLV-infected animals will go on to develop these cancers affecting lymph nodes and white blood cells. Tumors may occur in the spinal canal, uterus, heart, abomasum, kidney and/or lymph nodes. The most common clinical signs of cancer in cattle include anorexia, weight loss and fever or sudden death.

Blood testing is the first step to identify BLV-positive (infected) animals. Testing should be done in animals over six months of age and not around the time of calving in cows. Measures to control BLV include using single-use needles, cleaning and disinfecting equipment between animals with a disinfectant such as chlorhexidine, and implementing an integrated pest management program. Economic losses stem from the inability to sell cattle for export or as bull studs, condemnation of carcass at slaughter if tumors are present, and clinical disease/death loss.

Bovine Spongiform Encephalopathy

Bovine spongiform encephalopathy (BSE) is a chronic degenerative disease of cattle that affects the central nervous system. It was first diagnosed in the United Kingdom in 1987 and is considered rare in North America. BSE is also referred to as "mad cow disease."

This disease is not contagious and is believed to be caused by a prion. The only known method that cattle can contract BSE is through the consumption of animal by-products with infective material such as brain, spinal cord, retina, and distal small intestine. There is neither a treatment nor vaccine to prevent the disease. The incubation period (time from infection to symptoms) is two to eight years. Once clinical signs are seen, death usually occurs in two weeks to six months. Most cases have occurred in cattle between three and six years of age, usually dairy cattle.

As of 1997, Federal Drug Administration (FDA) prohibited the feeding of most mammalian protein to cattle. Several diseases in Kentucky are more common to cause central nervous system (brain) signs than BSE. These include listeriosis (circling disease), rabies, polioencephalomalacia (thiamine deficiency or high sulfur diet), grass tetany, milk fever, and ketosis. You should consult with your veterinarian for an accurate diagnosis if cattle are showing abnormal brain signs, such as staggering, excessive bellowing, or down (non-ambulatory).

Bovine Respiratory Disease

See "Pneumonia/shipping fever."

Bovine Respiratory Syncytial Virus

Bovine respiratory syncytial virus (BRSV) is a prevalent virus that can cause respiratory disease in cattle of all ages but primarily affects calves in outbreaks. BRSV is also considered a disease that predisposes animals to secondary bacterial infections. Vaccination can reduce severity and protect calves and cattle from disease. BRSV vaccines usually are in combination with other respiratory viral vaccines (IBR, PI_3, and BVD) and are available in modified-live or killed forms. Intranasal BRSV vaccines are often used in young calves as these vaccines stimulate immunity in the nose rather than relying on the immature immune system. BRSV can spread quickly in naïve cattle (3-10 days) and is found in the nasal and tracheal mucosa in infected calves, replicating and causing inflammation in these tissues. Clinical signs of BRSV can take two to four days to develop. BRSV infection is associated with high morbidity (60% to 80%), and fatality rates may be as high as 20%. BRSV can cause clinical disease in older heifers and adult cows, but generally older individuals will have less severe or subclinical BRSV infection.

Bovine Viral Diarrhea Virus

Bovine viral diarrhea virus (BVD) can cause a variety of clinical conditions, including abortions, birth defects, weak calves at birth, pneumonia, death, and persistent infections. The BVD virus is frequently diagnosed in Kentucky due to its immunosuppressive effect that increases susceptibility to respiratory disease, especially in recently weaned stocker calves. There are two forms of infection; a transient infection (TI) is an infection of short duration (usually 10 days to two weeks) during which time the calf is very susceptible to contract additional diseases because the virus stops the immune system from functioning. A persistent infection (PI), on the other hand, is a life-long infection a calf is born with but does not generally cause problems for the infected animal.

Persistently infected (PI) calves occur when a pregnant dam with inadequate protection (poorly vaccinated) is infected with BVD sometime during 40 to 125 days in gestation. The calf contracts the virus *in utero* and is born "persistently" or forever infected. A PI calf may be born undersized and have slower growth rates, or it may appear normal. The most efficient transmission source for the BVD virus is contact with PI cattle. A PI calf continuously sheds the virus from all secretions during its life. PI bulls can introduce BVD into a herd of cattle through the semen or direct contact. There is no treatment to remove the virus for cattle with persistent BVD infection.

Biosecurity plans should include isolation of newly acquired animals for at least two weeks and testing for the virus, either by an ear notch (skin) sample or a

serum sample. Limit movement of cattle on and off the farm, especially pregnant animals, to reduce the chance of exposure. Vaccination programs routinely are used to limit disease from BVD infection, especially prebreeding vaccines to promote fetal protection and prevent PI calves.

The commercial viral vaccines available are killed/inactivated or modified-live virus products. In general, modified-live vaccines should not be used in pregnant animals unless administered strictly according to the label directions. The killed BVD vaccines are safe for use in pregnant cows. When using a killed virus vaccine for the first time, a booster is required in two to four weeks after the first vaccination. Replacement heifers should be vaccinated at five to six months of age and booster this in two to four weeks according to label directions. Modified live vaccines are strongly recommended for replacement heifers.

Annual revaccination of the breeding herd is recommended prebreeding to get maximum fetal protection. All new additions should be screened for PI cattle with an inexpensive blood test or ear notch skin sample since PI animals serve as a continuous source of infection. A purchased pregnant cow or heifer may test negative herself but be carrying a PI calf so it is vitally important to test her calf at birth for persistent infection. Consult a veterinarian about the appropriate use of vaccines in your herd as well as testing procedures to identify and remove PI cattle. **Remember, PIs are considered defective and there is a legal, moral, and ethical obligation to dispose of these animals without sending/returning them to commerce.**

Brucellosis

Brucellosis (Bang's disease) causes abortion in cattle. More importantly, brucellosis can cause a disease in humans called "undulant fever." Cows with brucellosis shed large numbers of infectious organisms at calving. Calves receiving milk from infected cows shed live organisms in the feces. Kentucky is certified brucellosis free along with most of the United States except for a few Western states. Test and slaughter of infected animals is required by law. Prevention may include calfhood vaccination of heifer calves with RB51 strain vaccine between four to 10 months of age. Heifer calves must be vaccinated by an accredited veterinarian. Upon vaccinating a calf, the veterinarian will place an official tattoo and tag in the right ear and record the vaccination with the state veterinarian. Work with your veterinarian to determine if vaccination is necessary. Herds can be certified brucellosis-free with annual blood testing.

Coccidia

Coccidia are intracellular protozoan parasites that can cause serious economic losses due to weight loss, reduced performance and possibly death. The coccidian life cycle is complex. The single-cell oocysts are passed in the feces of infected cattle and "sporulate" to form the infective stage. The sporulated oocysts are consumed by a susceptible animal and attack the lining of the intestine. This development cycle in the intestinal tract destroys intestinal cells. The amount of damage done is directly related to the number of oocysts ingested. Outbreaks of bloody diarrhea are associated with the stresses of weaning, shipping, overcrowding and dietary changes.

Coccidiosis is primarily a disease of confinement. Affected animals may be off feed and strain to defecate, resulting in fresh blood in the manure and, in severe cases, rectal prolapse. Management techniques recommended to reduce exposure to oocysts include decreased stocking rates, minimizing stress, and providing clean housing. Feed should be kept off the floor to prevent contamination and waterers should be cleaned regularly. Use of the ionophores monensin (Rumensin®) or lasalocid (Bovatec®) or use of decoquinate (Deccox®) will help prevent coccidiosis. Do not allow horses to consume Rumensin® or Bovatec®. Cattle showing clinical signs of coccidiosis must be treated with drugs such as amprolium (Corid®) or sustained-release sulfas to cure clinical animals. Consult a veterinarian for treatment and prevention advice.

Cryptosporidia

Cryptosporidia are tiny protozoan parasites that invade the intestinal cells of the small and large intestine. It is a major contributor to calf scours/diarrhea and often becomes deadly in combination with a virus or bacterial agent. The disease is common in one- to four-week-old calves housed indoors. Cross infection between animals and humans is possible, so washing hands is advisable after handling young scouring calves. There are no medications available in the United States considered effective against cryptosporidia. They can survive for long periods in the environment, especially inside barns, so effective cleaning is imperative to prevent disease.

Foot Rot

Foot rot is an infectious disease characterized by sudden lameness and inflammation of the tissues between the claws. It is caused by injury to the skin between the claws, allowing infection with the bacteria *Fusobacterium necrophorum* and *Bacteriodes melaninogenicus*. The affected tissue becomes swollen and painful, and only light weight is placed on the toe. A characteristic foul odor is easily detected but little pus is observed. Treatment usually consists of systemic (injectable) antibiotics or treatment of the interdigital area with copper sulfate either by wrapping the hoof or by footbath. Prevention includes good nutrition (especially adequate zinc in the mineral preparation) and measures to ensure good hoof health such as improving drainage to reduce mud and manure buildup.

Histophilus somni (formerly Haemophilus somnus)

Histophilus somni is a normal bacteria found in the upper respiratory and urogenital tract of cattle but is a source of problems if it reaches the lungs or bloodstream. *Histophilus* can cause respiratory (pneumonia), heart, and brain disorders in feeder calves, and reproductive disorders in adult cattle. Commercial vaccines are available but have very limited success in inducing protection against disease. Thrombotic meningoencephalitis (TME) is a rapidly fatal brain disease in cattle due to *H. somni*.

Infectious Bovine Rhinotracheitis

Infectious bovine rhinotracheitis (IBR or bovine herpes virus-1) is the cause of viral respiratory and reproductive diseases affecting cattle. IBR can cause respiratory infections, abortion in cows exposed during pregnancy, infertility, and eye inflammation (conjunctivitis).

All forms of IBR can be controlled by vaccination with products for intranasal administration or injectable. Modified-live virus vaccines, in combination with BVD, BRSV and PI_3 for injection, are most effective but can cause abortion in pregnant animals if label directions are not carefully followed. Calves should be vaccinated 30 days before weaning and receive a booster dose at weaning or vaccinated at weaning and boostered two to four weeks later. Replacement heifers should be vaccinated again at least 30 days before breeding. The breeding herd should receive an annual booster dose, preferably modified live prebreeding.

Johne's Disease

Johne's disease (pronounced *yo-knees*) is a contagious bacterial infection of the intestinal tract of ruminants caused by the bacterium *Mycobacterium avium* subsp. *paratuberculosis*, commonly referred to as "MAP". This is a slow, progressive disease that begins when *calves* (not adult cattle) are infected with the MAP bacteria, most often around the time of birth but infection can occur up to 6 months of age and very rarely after. Johne's infection is mainly caused by calves ingesting MAP-contaminated feces from nursing dirty teats. In beef cattle, this is possible in high traffic areas (around hay rings, feeding areas) when mud and manure are splashed on the udder, when calving cows in dirty sheds or barns, or when cattle are held in close confinement. MAP is also shed in colostrum and milk of infected cattle. Once MAP gains entry into a calf, the organism lives permanently within the cells of the small and large intestine where it multiplies and causes the intestinal lining to slowly thicken. With time, the thickened intestine loses the ability to absorb nutrients, resulting in watery diarrhea. There is no blood or mucus in the feces and no straining. The clinical signs of diarrhea and extreme weight loss in spite of having a good appetite, do not show up until 2-5 years of age or even older. There is no treatment available and the animal eventually dies due to starvation and dehydration. The MAP organism begins to be "shed" in the feces years before diarrhea starts and continues until the animal's death. Map bacteria are very hardy due to a protective cell wall that allows survival for long periods (potentially 1-5 years) in the environment.

In almost all cases, the MAP bacteria arrived on the farm when an infected animal was purchased and added to the herd. The bacteria can be hiding in replacement heifers, cows, breeding bulls, recipients used for embryo transfer, or even in an infected calf purchased to graft on a cow. It is easy to buy (and sell) infected, young breeding age animals with no obvious symptoms even though they are already incubating the disease. However, these infected animals will shed the MAP organism, in increasing numbers as the disease progresses, contaminating the farm environment and increasing the risk of infection spread within the herd. MAP-contaminated colostrum from other herds, especially from dairies, is another potential source.

No treatment exists for Johne's disease. Cattle become shedders of the bacteria before they show clinical signs of diarrhea and weight loss. Cattle can be tested by collecting feces and submitting for PCR analysis or a blood test can be performed. A negative result does not guarantee the animal is negative; some animals with infection are slow to produce antibodies or shed the organism and are consequently slow to test positive.

The key to preventing, controlling, and eliminating Johne's disease in a herd is implementation of appropriate biosecurity measures including buying only from reputable sources and testing all new additions in the herd. Consult a veterinarian to develop a specific plan tailored for the herd.

Leptospirosis

Leptospirosis (often referred to as "Lepto") is a bacterial disease that causes abortions, stillbirths, and birth of weak calves. *Leptospira hardjo* (*L. borgpetersenii serovar hardjo*) and *pomona* (*L. interrogans serovar pomona*) are the two strains of primary concern for Kentucky cattle. The infection localizes in the kidneys and is shed in the urine to infect other cattle or humans. Prevention of leptospirosis is a good reason to keep cattle out of stagnant ponds.

All breeding-age female cattle should be vaccinated against the five strains of leptospirosis. Annual revaccination is highly recommended, especially when cattle are allowed access to farm ponds. Older leptospirosis vaccines have a short duration of immunity and require revaccination every three to four months to maintain adequate herd immunity. Recently, new vaccines against *L. hardjo bovis* (vaccines with the initials "HB") have been shown to protect against that strain and provide longer duration of immunity (up to one year) than the traditional Lepto-5 vaccines. The new vaccine does not eliminate carrier animals; treatment with oxytetracycline is necessary to eliminate carriers of leptospirosis.

Listeriosis

Listeriosis (circling disease, silage disease) is caused by the bacterium *Listeria monocytogenes* that is most often associated with feeding moldy silage or baleage, especially during cool weather. Animals show neurologic disease and may display head pressing, drooped ear, and/or compulsive circling. The recovery rate is best if treatment is administered early in the course of the disease. Listeria may also cause abortion and eye lesions. Prevention includes discarding moldy feed, especially fermented feeds, and cleaning contaminated areas. Rule out other diseases that can cause similar signs, especially rabies.

Neosporosis

Neosporosis is caused by a protozoan parasite *Neospora caninum.* The protozoa may affect the developing fetus, but it does not cause clinical illness in the adult. Once infected, the cow is infected for life and there is no effective treatment. Depending on when exposure to *Neospora* occurs during gestation, infection may result in fetal death, abortion, stillbirth, or birth of weak calves. In future pregnancies, normal calves may be born already infected with the organism and can pass it on to their offspring. The disease is primarily a problem in dairy cattle but is increasingly found in beef cattle. Abortion epidemics may occur if feed is contaminated with the organism.

The dog and the coyote have been identified as the definitive hosts and is where the parasite produces the infective eggs (oocysts). Cattle are exposed to *Neospora caninum* with accidental ingestion of feed or water contaminated with dog or coyote feces containing the oocysts. Cows can be blood tested to determine if they have

been infected. Diagnosis of the infection in affected calves is based on heart and brain abnormalities in the calf or aborted fetus, abnormalities in the placenta and positive blood tests. A vaccine was available but has been withdrawn from the market.

Parainfluenza Type 3

Parainfluenza type 3 (PI-3) primarily causes mild respiratory problems in cattle. It is considered to be a secondary factor in shipping fever outbreaks. Effective vaccines are available, including intranasal vaccines or modified-live and/or killed vaccines for injection. PI-3 vaccines are usually given in combination with IBR, BVD, and BRSV.

Pinkeye

Pinkeye (infectious bovine keratoconjunctivitis) in cattle is characterized by inflammation and watering of the eye, painful sensitivity to light, and varying degrees of corneal damage. Research in Kentucky indicates a definite decrease in weaning weight of calves with pinkeye. This decreased performance, coupled with a decrease in selling price of affected calves, can mean significant losses for Kentucky beef producers.

Pinkeye is caused by the bacteria *Moraxella bovis*. These bacteria are covered with hair-like structures used to attach to the cornea or clear portion of the eye. Once attached, it releases a toxin that kills cells on the surface of the cornea. Early detection and prompt effective treatment are essential to reducing spread and limiting damage to eye. The earliest signs include a large amount of watery tears that often flow down the face, excessive blinking, squinting, and sensitivity to light. In 1 to 2 days, the cornea appears white and a small ulcer or "pit" develops towards the center of the eye. Some cases will resolve while others progress to deep ulceration and corneal rupture.

Treatment with a long acting antibiotic along with topical fly repellant is the best course of action to reduce the spread of pinkeye in the herd. Active cases of pinkeye with excessive tearing attract flies that spread the bacteria quickly. Work with a veterinarian to determine the best antibiotic for the situation. Isolation of the affected animals will also help limit the spread. A patch can be used to protect an affected eye however it is difficult to see if the eye is improving or deteriorating when covered. If the case of pinkeye is very advanced, a veterinarian may suture the eyelids together or use a third eyelid flap to stabilize the cornea. Do not rely on sprays alone since they remain in the eye just a few minutes before tears wash them away. To be effective, sprays must be applied 3-4 times daily. Vaccination alone will not prevent disease but may allow faster response to treatment. An overall good level of nutrition, adequate vitamin and trace mineral intake, a comprehensive vaccination program, and parasite (fly) control are all exceptionally important in improving an animal's ability to fight off any disease process. To reduce as many of the pinkeye risk factors as possible, prevent corneal damage from sun by providing shade, control face flies, clip pastures to prevent mechanical injury from grass and plants, and provide an abundant clean water source in order to keep calves hydrated, allowing the eye to stay clean and moist. Recent eye cultures have indicated that *Moraxella bovoculi* also contributes to pinkeye, especially cases in the winter months. Some veterinarians have autogenous vaccines prepared from pinkeye cases cultured on the farm to stimulate immunity against both *M. bovis* and *bovoculi.*

For further information, see ID-135: *Infectious Bovine Keratoconjunctivitis ('Pinkeye') in Cattle* (http://www2.ca.uky.edu/agc/pubs/id/id135/id135.pdf).

Pneumonia/Shipping Fever/Bovine Respiratory Disease Complex

Pneumonia/shipping fever/bovine respiratory disease (BRD) is caused by a complex interaction of bacterial and viral organisms along with stress in an animal, leading to infection and inflammation of the lungs. Clinical signs include depression, fever, off-feed, an increase in the rate and depth of respiration, cough, nasal discharge, and open-mouth breathing. BRD is associated with the stress reaction to changes in diet, a new environment, weather, water, dehorning, castration, weaning, handling, confinement, hauling, and mixing with new groups of calves.

Several viruses are major contributors to BRD. They are highly contagious and include bovine respiratory syncytial virus (BRSV), bovine viral diarrhea virus (BVD), infectious bovine rhinotracheitis (IBR), and parainfluenza (PI3). Bacterial agents are ultimately responsible for the severe lung damage. Bacteria take advantage of stress and viral infection to overcome the immune defenses and cause pneumonia. *Mannheimia* (formerly Pasteurella) *haemolytica* is the bacterium that often causes "shipping fever pneumonia," especially in stocker and feedlot cattle. These bacteria can cause severe pneumonia and result in quick death if the animal is not treated with effective antibiotics early in the course of disease. *Pasteurella multocida, Histophilus somni,* and *Mycoplasma bovis* are other bacterial species that can contribute to pneumonia (Table 7-3).

Successful treatment of BRD involves early recognition of sick animals, appropriate treatment, follow-up, and prompt retreatment of relapses. Clinical signs include depression (Table 7-4), decreased appetite (Table 7-5), abnormal breathing (Table 7-6), and fever on examination (Table 7-7). Coughing is not always present early in pneumonia. It is important to watch cattle at feeding time. Sick calves may walk to the bunk but not eat.

Antibiotics and other therapeutic agents should be selected on the basis of symptoms shown and with a protocol developed with a veterinarian. Often bacterial organisms become resistant to an antibiotic that has worked well in the past and a new antibiotic must be selected. Mass treatment of all calves (metaphylaxis) should be considered if sickness is expected in a group of high-risk calves or if increasing rapidly. A hospital pen is an option so sick animals can be closely observed and easily treated but must be cleaned and sanitized regularly.

Prevention includes reducing stress and exposure while promoting resistance to infection. Preconditioning is one successful approach. This management and marketing program significantly reduces illness and death due to BRD. The Kentucky Certified Preconditioned for Health CPH-45 program ensures that the calves have been vaccinated, weaned a minimum of 45 days and have learned to eat from a feed bunk and drink water from a trough. The calves must be offered a free choice mineral with minimum specifics for copper, selenium, zinc, manganese, and salt content. The program includes required vaccinations (IBR, PI-3, BVD,

BRSV, and 7-way clostridial) and treatment for internal and external parasites. Some sales require specific vaccine and parasite products, so always check with the sale location for their requirements and timeline. There is a guarantee that the calves do not include bulls, stags or pregnant heifers. The producer certifies that the procedures are done according to required BQA standards.

Salmonellosis

Salmonellosis is a disease that causes diarrhea in calves and adults. It can lead to multiple deaths in a herd. "Salmonellae" is a collective term used for the many different serovars of *salmonella* bacteria that are known to infect cattle. Salmonellae are invasive bacteria that can penetrate intestinal, oral, ocular, or nasal mucous membranes. Cattle are primarily infected with salmonellae by three methods:

- **Transmission by wildlife.** Rodents and birds can bring in salmonellae from outside sources or act to maintain the infection by infecting cattle feed.
- **Being fed contaminated animal protein by-products.** The bacteria can rapidly multiply in high-moisture feeds after contamination by birds, rodents, or equipment.
- **Transmission by cattle and other livestock.** Asymptomatic and sick cattle can shed large numbers of the bacteria in the feces into the environment while appearing healthy.

A link between intensive management practices, such as crowded conditions and high-protein diets, and an increased incidence of salmonellosis has been suggested. Stress factors play an integral part in the disease. Stresses include transportation of animals, inadequate nutrition, bad weather, overcrowding, parturition, and concurrent disease. *Salmonella* may affect calves already infected with rotavirus, coronavirus, or cryptosporidia. If the challenge dose of salmonella bacteria is large enough, salmonellosis may occur as a primary disease in older healthy cattle. The risk of disease may be greatest when the infection occurs in a herd that is under environmental or nutritional stress and is close to calving. Newer vaccines have improved efficacy against salmonellosis.

Table 7-3. Common causes of pneumonia.

Viral agents	Bovine Respiratory Syncytial Virus	BRSV
	Bovine Viral Diarrhea Virus*	BVD
	Infectious Bovine Rhinotracheitis	IBR
	Parainfluenza Virus Type 3	PI-3
Bacterial agents	*Histophilus somni* (*Haemophilus somnus*)	
	Mannheimia (Pasteurella) haemolytica	
	Mycoplasma bovis	
	Pasteurella multocida	

* Important cause of secondary pneumonia due to immunosuppression.

Table 7-4. Depression (attitude).

	Abnormal		
Normal	*Mild*	*Moderate*	*Severe*
• Bright • Alert • Moves with other animals	• Head lowered • Ears drooped • Eyes dull • Easily stimulated to move • Stiff gait	• Listless • Stiff gait • Stiff upon rising • Hunched up • Does not respond but moves when urged	• Looks very sick • Does not get up

Table 7-5. Appetite.

Normal	**Abnormal**
• Approaches feed when placed in bunk or trough	• Appears gaunt (empty) in left flank • Not interested in drinking • Does not immediately walk toward the feed when fed

Table 7-6. Respiratory index.

Normal	**Abnormal**
• Breathes in and out easily • No exaggerated motion • Inspiration and expiration performed at a normal rate	• Flared nostrils at inspiration • Extended neck to open airway • Open-mouth breathing • Shallow breathing • Exaggerated deep breathing • Soft, persistent cough • Drooling

Table 7-7. Temperature.

Normal	**Abnormal**
• Body temperature is 102.5°F when checked in the early morning	• Body temperature is 104°F or higher*

* Elevated body temperature may also be caused by heat, high humidity levels, animal's exertion before entering handling facilities, dark hair color, and consumption of high-endophyte fescue in the summer.

Scours/Diarrhea

Scours (neonatal diarrhea) is the most common infectious problem of young beef and dairy calves. Scours/diarrhea is caused by a number of infectious organisms (Table 7-8). The three basic factors involved with development of scours are: (1) a contaminated environment where the animals are born and raised, (2) poor quality and/or quantity colostrum consumption, and (3) infectious agents (viral, bacterial, or protozoal). One or more of the infectious agents damage the calf's

Table 7-8. Common causes of calf scours.

Infectious Causes	**Age Affected**
E. coli	1-5 days
Clostridium perfringens	2-10 days
Salmonella	1-4 weeks
Rotavirus	1-4 weeks
Coronavirus	1-6 weeks
BVD	2-6 weeks
Cryptosporidia	1-6 weeks
Coccidia	> 3 weeks

intestine and cause scours. Events leading up to infection and disease are the result of interaction among all three factors.

Calf Scours Treatment

- Identify, record information, and if possible, isolate the calf with its dam from healthy herd.
- Use oral (esophageal) feeder if the calf is weak and will not suckle. Use electrolytes to rehydrate calf and to help reduce the depression. Commercial electrolyte solutions are best as they provide the optimal combination of ingredients to correct fluid deficits and provide energy.
- A nonsteroidal anti-inflammatory drug such as Banamine® is useful to decrease pain and fever but overuse can result in ulcers in the digestive tract. Intestinal protectants and motility modifiers such as Kaopectate® are not recommended.
- Consult with a veterinarian concerning the use of antibiotics and/or the need for IV fluid therapy. Calves with diarrhea have an increased number of coliform bacteria in the small intestine regardless of the original cause so calves generally recover faster with antibiotic therapy. IV fluid therapy is needed in cases with severe depression, inability to stand, a weak suckle reflex and a low rectal temperature.

How to Use an Esophageal Feeder

- Prior to tubing the calf, examine the feeder to make sure it is clean and undamaged.
- The length of the tube and the size of the calf will dictate how far the tube should be inserted. Compare the tube length to the distance between the mouth of the calf and the point of the shoulder. This is the approximate distance the tube should be inserted.
- The calf should be standing if possible. Place its rear end into a corner and hold its head between your knees. If the calf won't stand, at least sit it up on its sternum (breastbone) and hold the head between your legs.
- To insure that no fluid runs into the mouth of the calf that could be inhaled in the lungs, either kink the plastic tubing or clamp it off during passage.
- Moisten the end of the feeder (the ball) with milk or vegetable oil to make it more slippery.

Table 7-9. Producer's worksheet: Herd assessment for calf scours.

Areas of Assessment	Yes	No	Points for Your Farm
1. Herd performance analyzed	0	5	
2. Forages tested	0	5	
3. More than 2% abortions (2 cows per 100 calves)	5	0	
4. Calve before March 10	5	0	
5. More than 20% first-calf heifers	20	0	
6. History of significant calf diarrhea	15	0	
7. Average Body Condition Score (BCS) less than 4	5	0	
8. Winter weight loss	15	0	
9. Premature calves (more than 30 days premature)	10	0	
10. Poor drainage in calving area	10	0	
11. Sick cows/calves remain in calving area	15	0	
12. Heifers calved separately from cows	0	10	
13. New additions (cows, calves, bulls) especially from sales barn	15	0	
14. Foster calves from outside sources	20	0	
Total score*			

* Total score of 55-70 indicates higher risk for calf diarrhea.

- Stimulate the calf to open its mouth by putting pressure on the gums or pressing on the roof of the mouth with your fingers. Do not hold the nose straight up; position the nose below the ears to reduce the risk of trauma to the back of the throat.
- Gently insert the tube into the mouth over the top of the calf's tongue. When the rounded end hits the back of the tongue where there is a ridge, the calf should swallow. Wait patiently until the calf swallows then slide the tube gently down the esophagus.
- Prior to administering the fluid, check that you feel the tube in the esophagus on the left side of the calf's neck. You should feel two tube-like structures in the neck: 1) the trachea (or windpipe) is firm and has ridges of cartilage all along its length, and 2)the esophageal feeder tube in the throat is firm but smooth.
- Administer the fluid by raising the bag above the calf and allowing the fluid to flow by gravity. Never squeeze the bag to hurry the process. The calf will begin to move (and vocalize) when it feels pressure as the rumen fills. Do not remove the tube until the fluid has had time to empty into the rumen.
- Again, kink the plastic tube or use a clamp before pulling the tube out in one swift motion.
- Immediately wash the tube and feeder in hot, soapy water. Follow with a chlorine and hot water rinse in order to remove the film of fat and protein that adheres to the inside of the feeder. If not properly cleaned and disinfected, there is a risk of inoculating bacteria directly into the intestinal tract when a calf is most vulnerable to infections.
- Keep the feeder in good repair-change them when it begins to show any signs of wear. Use a different esophageal feeder to deliver colostrum to newborn calves than the one used to treat scouring calves.

Calf Scours Prevention

- Decrease numbers of organisms in the environment with pasture management. Reduce stress: avoid crowding, provide adequate shelter, and keep cow teats out of the mud. Do not calve out cows in the same area used for confined winter feeding. It is best to separate heifers from the older cows before calving and return together after breeding (Table 7-9).

- Ensure that an adequate amount of good quality colostrum is consumed at birth.
- Provide the recommended nutrition (both protein and energy) and proper amounts of trace minerals, especially copper and selenium, to the cow during her pregnancy.
- Vaccinate the dam at the end of pregnancy to protect the calf through colostrum for *E. coli*, rotavirus, and coronavirus, and *Clostridium perfringens Type C* or administer vaccine to the calf by mouth at birth *before* the ingestion of colostrum.

Vibriosis

Vibriosis is a sexually transmitted disease caused by *Campylobacter fetus* sp. *veneralis* that causes early abortions and temporary infertility in the cow. The disease is spread through venereal transmission from an infected bull to females. Cows with previous exposure to infected bulls develop immunity and may be less likely to experience infertility than heifers. Infected heifers usually return to estrus in 6 weeks after the infection is cleared.

Treatment is difficult. Prevention is accomplished by vaccinating cattle before the start of breeding season. Bulls should also be vaccinated. Take precautions when adding breeding stock to the herd ("borrowing bulls") to prevent introducing the disease.

Forage-Related Disorders

Bloat

Ruminal tympany, or bloat, occurs due to a buildup of fermentation gases in the rumen. These gases are normally eructated or "belched" out of the animal. When this gas is prevented from escaping the rumen, it builds up, and stretches the rumen. As the pressure in the rumen increases, breathing becomes difficult because the diaphragm cannot expand so the lungs cannot inflate. In severe cases, death occurs from suffocation. Bloat potential is greatest during rapid growth periods in spring and declines during summer; generally mid-March through May in Kentucky.

Cause

Legumes and succulent cereal grain forages such as rye and wheat are considered high risk for promoting frothy bloat. Pasture bloat is usually associated with cattle grazing white (ladino) clover or alfalfa, and occasionally red clover. When these forages are at a vegetative stage, they are high in soluble protein, low in lignin, and have a highly digestible cell wall which can cause the formation of a slime that traps the fermentation gases and rumen contents, resulting in a foam (similar to the foamy head of a beer) that prevents the gas from being expelled. This type of bloat is termed "frothy" bloat because it is due to a foam rather than free gas. Other legumes, including lespedeza, crown vetch, and birdsfoot trefoil, rarely cause frothy bloat, in part due to a tannin content that lowers the digestion rate and yield of the soluble protein fraction.

Clinical Signs

Frothy bloat may occur on the first day of turnout but is more commonly seen on the second or third day. The main clinical sign is a swelling of the left region of the abdomen. Other possible signs include repetitive standing up and lying down, kicking at the belly, frequent defecation and urination, grunting, and extension of the neck and head. The animal will develop difficulty breathing when there is extreme pressure exerted on the diaphragm by the gas-filled rumen. Without treatment, the animal will collapse and die, generally three to four hours after clinical signs begin.

Treatment

To properly treat animals, the severity of the condition has to be accurately assessed. If the animal's life is not in immediate danger, passing a stomach tube and administering an antifoaming agent is recommended. Antifoaming agents include vegetable oils (peanut, corn, soybean), mineral oil, and "non- ionic surfactants" that will break up the stable foam and allow the gas to escape. Vegetable and mineral oils work equally well in the rumen. The most common non-ionic surfactant treatment is the poloxalene drench concentrate (Therabloat®). The recommended dosage for oils is between 80 and 250 ml/head and of Therabloat® is 1 to 2 fluid ounces, depending on the animal's weight.

The animal must be observed carefully for at least an hour after treatment to determine if the treatment was successful or if an additional therapy is needed. If the bloat does not resolve with treatment, the rumen can be punctured with a trocar and a cannula placed in the rumen. This procedure should be performed after acquiring proper training from a qualified individual, such as a veterinarian. If the bloat is severe when the animal is found, pressure inside the rumen must be alleviated immediately. In life-threatening cases, an emergency rumenotomy can be performed, in which a large hole is cut through the skin into the rumen, resulting in a sudden release of the rumen contents to the outside, relieving the pressure. Cattle typically recover with proper care of the incision and antibiotics.

Prevention

- Grow grass-legume mixtures instead of pure legumes. As the proportion of legumes exceeds 50% of the stand, the risk of bloat greatly increases.
- Avoid grazing very immature white clover or alfalfa. Research shows alfalfa grazed less than 10 inches tall had two times more bloat than when it is grazed at 19 inches.
- Moisture plays a role in a forage's bloat potential. Hungry cattle graze more aggressively when moved to a pasture, so they should not be moved to a new pasture with high legume content until midday—after the dew has dried and after they have grazed in the morning.
- Provide a full feeding of hay before turning animals into lush legume stands for the first time. High-quality grass hays that are palatable should be provided to encourage hay intake. Continue to offer access to this high quality grass hay for several days after turning into lush legume pastures.
- Although bloat is associated with certain plants, some animals have a genetic predisposition to bloat and these should be culled.
- The use of ionophores, a class of feed additives that inhibit growth of certain microbial species in the rumen, has proven effective in reducing the potential for legume bloat. Monensin is more effective than lasalocid and is the recommended ionophore for bloat control.
- Feed bloat-reducing compounds. The most common antifoaming surfactant and the only one currently approved for use in the United States

is poloxalene, which is frequently incorporated into a small block form. Most blocks are labeled to be fed at a rate of one block to every five head of grazing cattle. Poloxalene also comes in a loose granular form that can be mixed in with salt, mineral supplement, or some other feedstuff. When bloat risk is high, the recommended intake level is 2 grams per 100 pounds of body weight. When the risk is low, the feeding rate can be lowered to 1 gram per 100 pounds of body weight, but remember that animals need to consume the recommended dose for effective bloat prevention.

For further information, see Extension Fact Sheet ID-186: *Managing Legume-Induced Bloat in Cattle*.

Fescue Toxicosis

Fescue toxicosis and summer slump are terms widely used to denote poor performance of animals grazing tall fescue during the summer. This poor performance is due to the presence of high levels of a fungus in the fescue—the endophyte *Neotyphodium coenophialum,* that produces ergot alkaloids, especially ergovaline. Tall-fescue pastures containing ergot alkaloids are responsible for the toxic effects observed in livestock, including hyperthermia (elevated body temperature), gangrene of the extremities, decreased weight gain, and poor reproductive performance. The alkaloids cause vasoconstriction or narrowing of the arteries which leads to poor blood supply to many body systems. Hot, humid weather increases the negative effects.

Cattle consuming fescue infected with high levels of the fescue endophyte show some or all of the following symptoms:

- Lower feed intake
- Lower weight gains
- Lower milk production
- Decreased pregnancy rates
- Long, rough hair coat
- More time spent in the shade or mud due to higher body temperature

At least three areas should be considered to avoid or minimize the effect of the endophyte in animal production:

- **Manage to minimize the effect.** Clipping seed heads or chemically suppressing seed head development eliminates the most concentrated source of the endophyte and helps keep the plants vegetative. Hay harvested at the proper stage of maturity also gives better animal performance than late-cut hay.
- **Dilute out the endophyte.** The most practical way is to add legumes, such as clovers, to the fescue pasture. Even small amounts of legumes can increase animal gains.
- **Replace infected stands with low-endophyte varieties.** Several low-endophyte or endophyte-free varieties are now available. When choosing new varieties, pay attention to adaptability, forage production, animal performance, persistence, and pest resistance. These new varieties require good grazing management to persist in a stand.

For more information, see Chapter 2, "Forages for Beef Cattle," or see ID-221: *Fescue Toxicosis* at http://www2.ca.uky.edu/agc/pubs/ID/ID221/ID221.pdf.

Grass Tetany

Hypomagnesemic tetany or "grass tetany" is a disorder caused by an abnormally low blood concentration of the essential mineral magnesium (Mg). Synonyms for this disorder include spring tetany, grass staggers, wheat pasture poisoning, or lactation tetany. Grass tetany is considered a true veterinary emergency requiring prompt treatment with magnesium to prevent death.

Cause

Hypomagnesemia occurs most often in beef and dairy cows in early lactation because of the large demand for magnesium during lactation and the cow's limited ability to mobilize magnesium reserves within her body. Affected cattle are often found to have concurrent low blood calcium. Typically, this disease occurs when grazing annual ryegrass, small grains (such as wheat or rye) and cool season perennial grasses (tall fescue, orchardgrass and Kentucky bluegrass) in late winter and early spring (Feb-April). Fast-growing spring grass is often high in potassium (K^+) and nitrogen (N^+) and low in magnesium (Mg^{++}) and sodium (Na^+); each of these factors contributes to decreased absorption of magnesium through the rumen wall. "Winter tetany" in beef cattle is another form of hypomagnesemia caused by consuming low energy forages with low concentrations of magnesium over a long period of time, usually throughout winter. Clinical signs of grass tetany are then triggered by a stressor such as a cold weather snap.

Clinical Signs

Grass tetany or hypomagnesemia often causes sudden death in older lactating beef cows weeks or even months after calving without appropriate supplementary mineral feeding. The hypomagnesemic cow is most often found dead with disturbed soil around its hooves indicating paddling/seizure activity before death. If seen in the acute stage, grass tetany is characterized by hyperexcitability (nervousness), tetany (constant contraction of muscles resulting in muscle stiffness and rigidity), convulsions and then death. The earliest signs of twitching of the facial muscles, shoulder, and flank are due to the uncontrolled activation of peripheral nerves. Affected cows become separated from the group and have a startled expression, show an exaggerated blink reflex, frequent grinding of the teeth, and may show aggression. As the fall in blood magnesium progresses, sustained muscle spasms become more common, eventually causing the cow to stagger and fall. Convulsions and seizures quickly follow, with chomping of the jaws and frothy salivation. Affected animals lie with the head arched back and the legs paddling. The heart rate may reach 150 beats per minute (approximately twice the normal rate) and can often be heard without the use of a stethoscope. Respiratory rates of 60 breaths per minute (normal is 10-30 breaths per minute) and a rectal temperature as high as 105°F may result from the excessive muscle activity. Animals may get up and repeat these convulsive episodes several times before they finally die. The diagnosis is made based on history, clinical signs, and low magnesium concentration in the blood, spinal fluid, or eye fluid.

Treatment

Animals exhibiting grass tetany are in need of immediate veterinary treatment; preferably 1.5-2.25 grams of magnesium intravenously for an adult cow. Tranquilization by the veterinarian may be needed to reduce the risk of injury during treatment. Response to therapy is not always good and depends largely on the length of time between onset of symptoms and

treatment. Cattle that do recover take at least an hour which is the time it takes for spinal fluid magnesium levels to return to normal. Many of these cows will relapse and require more treatment within 12 hours. Administering oral magnesium gel once the animal has regained good swallowing reflexes or drenching with magnesium oxide or magnesium sulfate will reduce the rate of relapse.

Prevention

- Provide a high magnesium mineral supplement at least 30 days prior to calving. Cows require approximately 17-20 grams of magnesium daily or 4 ounces per day of a 15% magnesium mineral mix during the late winter and early spring. UK Beef IRM mineral recommendations for free choice supplements for grazing beef cattle include 14% magnesium in the trace mineral mix and all from magnesium oxide (no dolomitic limestone or magnesium mica). These complete mineral mixtures also supply additional sodium in the form of salt to aid in combatting high potassium intakes. Consumption should be monitored because magnesium is not palatable and mineral intake is generally inadequate if using poor quality mineral products. High magnesium mineral may be discontinued in late spring once the grass is more mature, the water content of the forage is decreased, and daily temperatures reach at or above 60°F.
- Feeding ionophores (monensin, lasalocid) has been shown to improve magnesium absorption efficiency.
- Soil test and apply fertilizer based on soil test results and use no more potassium than recommended since grasses are often luxury consumers of potassium.
- Legumes are high in magnesium and will help offset the problem although their growth is limited in late winter.
- Limit grazing to 2-3 hours per day with free-choice access to high quality hay for early lactation cattle on lush pasture during susceptible periods or graze the less susceptible animals (heifers, dry cows, stocker cattle) on the higher risk pastures since the threat of disease is very low in non-lactating cattle.

For further information, see ID-226: *Hypomagnesmic Tetany or Grass Tetany*, http://www2.ca.uky.edu/agc/pubs/ID/ID226/ID226.pdf.

Nitrate Toxicity

Nitrates are present in all plants, but normally their concentrations are not excessive. Under normal growing conditions, nitrate from the soil is absorbed by the roots of forage plants, and is supplied to the leafy upper portions of the plant where it is converted into plant protein. However, adverse environmental conditions such as drought, sudden weather changes (cool, cloudy weather), leaf damage (due to hail, frost, or herbicides), or heavy fertilization with nitrogen, can cause plants to develop and retain potentially dangerous levels of nitrate. The lower stalks and stems at the base of the plant are the site of highest accumulation. Nitrate levels will remain high until there is new leaf growth. Hay will remain a hazard because toxicity is unchanged by drying, but the nitrate concentrations in ensiled forage crops may be reduced by up to 60% with proper fermentation and microbial degradation.

Cause

Drought-stressed sorghum, sorghum-sudangrass or corn are the source of most of the forage-related cases of nitrate poisoning in Kentucky, but wheat, sudangrass, rye, pearl millet, soybeans, beets, Brassica spp. (rape, kale, turnips, swedes) and oats can also accumulate nitrates. Common weeds that are nitrate accumulators include ragweed, pigweed, thistle, bindweed, dock, jimsonweed, and Johnsongrass. Although these are not complete lists, these weeds and forages are the most problematic. Surface water or water from shallow wells may contain nitrates, especially if there is run-off from fertilized land contaminating the water. Both water and forage should be analyzed to ensure that total nitrate does not exceed toxic levels.

Nitrate poisoning in ruminants may also result from consumption of nitrate fertilizer. Cattle that gain access to stored nitrate fertilizers, especially when deprived of salt, may consume toxic quantities very quickly. The highest number of nitrate toxicity cases brought to the UK Veterinary Diagnostic Lab result from the consumption of fertilizer.

Nitrates enter the bloodstream as nitrite, which combines with hemoglobin in red blood cells to produce methemoglobin, a form incapable of transporting oxygen. Death occurs as a result of asphyxiation as methemoglobin levels approach 80%. Nitrate and nitrite poisoning can occur in all animals but cattle are considered most susceptible because of the rapid conversion of nitrate to the more toxic nitrite form by rumen microorganisms.

Clinical Signs

The first indication of nitrate toxicity may be the discovery of one or more dead animals while others may be exhibiting clinical signs. Signs of nitrate poisoning in an animal include weakness; rapid, labored breathing; rapid, weak heart beat; staggering; muscle tremors; and recumbency (inability to stand). Affected animals typically show signs of poisoning within a few hours after consumption of a toxic dose of nitrates. Examination of the mucous membranes, especially the vaginal mucous membranes, may reveal a brownish color. Chocolate-colored blood and a brownish cast to all tissues are hallmark signs of nitrate poisoning. Most deaths occur within the first 6-8 hours after onset of clinical signs and largely depend on the quantity and rate of absorption of nitrite and the amount of stress or exercise the animal is forced to do. After death, nitrate concentration can be accurately measured in the eye fluid. Pregnant cows that survive toxicity will likely abort 3-7 days following recovery from nitrate poisoning.

Treatment

Animals showing signs of nitrate poisoning should be quietly removed from the source of toxicity and a veterinarian should be contacted immediately. Administration of a 2% solution of methylene blue intravenously by the veterinarian will aid in converting methemoglobin back to hemoglobin.

Prevention

- Nitrate fertilizer should be stored where cattle do not have access to it and accidental spills should be cleaned up promptly. Check field pastures closely

after custom applications to make sure "piles" are not left at the edges of the field due to incomplete turnoff of the applicator.

- Avoid grazing warm season grasses fertilized with high amounts of nitrogen (from fertilizer or manure) when growth ceases due to drought, cold damage, hail, or herbicide exposure. Warm season grass stands that have received multiple sources of nitrogen (such as nitrogen fertilizer, manure, previous legume crops) can occasionally show elevated nitrate levels without environmental stress. When in doubt, take the time to send samples for nitrate testing before introducing cattle to the pasture.
- Cool season grasses and small grain pastures that have been heavily fertilized with nitrogen may be high in nitrates during early spring when cool, overcast days retard growth. Test before grazing.
- Corn should be properly ensiled at least 4-6 weeks and tested for nitrates before feeding. Do not green chop forages suspected to be high in nitrates.
- All suspected forages including silage and hay should be tested for nitrate levels. A field test is available to give a quick indication if the forage is potentially dangerous. If the test strip reacts, a forage sample should be sent to a laboratory for an accurate analysis of nitrate and a feeding recommendation. Consult your County Extension Agent for Agriculture for information concerning sampling, sample preparation, field test, and location of a testing laboratory.
- Forage with high nitrate levels can be mixed with forage known to be low in nitrate to reduce the risk from feeding (Table 7-1).
- Feeding low nitrate forage or hay before turning cattle on to high nitrate forages will reduce the amount of nitrate consumed. Splitting grazing times will also allow nitrates to be utilized properly by the rumen microflora.
- Cattle have the ability to increase their tolerance to nitrates in their diet with time. A period of adaptation of at least a week is recommended. To aid in increasing this tolerance, the diet should be sufficient in vitamins and trace minerals.
- A gradual increase in the total energy content of the ration enhances metabolism in the rumen and helps cattle tolerate higher nitrate levels in their diet. This may be in the form of a high carbohydrate feed such as corn that helps microbes convert nitrates to protein.
- Delay harvest of high nitrate forages until nitrate levels are safe. If not feasible to delay harvest, raise the cutter bar to 18" to avoid the base of plants.
- Propionibacterium products are available in bolus or powder form that reportedly reduce nitrate and nitrite levels in the rumen by approximately 40%. These products must be established in the rumen for at least 10 days before allowing cattle to consume high nitrate feedstuffs.

For further information including testing guidelines, see ID-217: *Nitrate Poisoning* at http://www2.ca.uky.edu/agc/pubs/ID/ID217/ID217.pdf.

Cyanide or Prussic Acid Poisoning

Prussic acid, cyanide, or hydrocyanic acid are all terms relating to the same toxic substance. Cyanide is one of the most rapidly acting toxins that affect cattle.

Cause

The cause of cyanide poisoning in ruminants is the ingestion of plants containing cyanogenic glycosides. When plant cells are crushed, chewed, wilted, frozen, chopped or otherwise ruptured, the cyanogenic glycosides and the enzymes that convert them can physically come together and rapidly form free cyanide. As ruminants consume these plant materials, hydrogen cyanide gas is produced in the rumen and rapidly absorbed into the bloodstream. Cyanide prevents hemoglobin in red blood cells from releasing oxygen to the tissues and the animal dies from lack of oxygen.

Cyanide poisoning of livestock is commonly associated with Johnsongrass, sorghum-sudangrass, and other forage sorghums after frost, but poisoning can occur without frost. Choke-cherry or wild cherry, and elderberry are less frequent causes. Young plants, new shoots, and regrowth of plants after cutting often contain the highest levels of cyanogenic glycosides. Leaf blades are higher risk than leaf sheaths or stems, upper leaves are higher risk than older leaves, and seed heads are considered low risk. Hay is rarely hazardous if adequately cured. Ensiling plants will significantly reduce the cyanogenic glycoside content.

Clinical Signs

Cyanide is one of the most potent toxins in nature. Affected animals rarely survive more than 1-2 hours after consuming lethal quantities of cyanogenic plants and usually die within 5-15 minutes of developing clinical signs of poisoning. Signs may include rapid labored breathing, irregular pulse, frothing at the mouth, dilated pupils, muscle tremors, and staggering. The mucous membranes are bright red in color due to oxygen saturation of the hemoglobin. Diagnosis is difficult since cyanide is rapidly lost from animal tissues unless collected within a few hours of death and promptly frozen. Cyanide concentration determinations in suspect plants can be performed if samples are frozen immediately or sent on ice overnight to a diagnostic laboratory.

Treatment

Contact a veterinarian immediately if cyanide poisoning is suspected. The intravenous administration of sodium thiosulfate is an effective treatment for cyanide poisoning. Most animals that live after treatment will recover completely.

Prevention

- Graze sorghum, sorghum crosses, or Johnsongrass plants only when they are at least 18-24 inches tall. Young rapidly growing plants or regrowth have the highest concentrations of cyanogenic glycosides, especially in the newest leaves and tender tips. Do not graze plants with young tillers.
- Do not graze plants during drought periods when growth is severely reduced or the plant is wilted or twisted. Drought increases the chance for cyanide because slowed growth and the inability of the plant to mature favors the formation of cyanogenic compounds in the leaves. Do not graze sorghums after drought until growth has resumed for 4-5 days after rainfall.
- Do not graze potentially hazardous forages when frost is likely (including at night). Frost allows conversion to hydrogen cyanide within the plant. Do

not graze for two weeks after a non-killing (>28 degrees) frost. It is best not to allow ruminants to graze after a light frost as this is an extremely dangerous time and it may be several weeks before the cyanide potential subsides. Do not graze after a killing frost until plant material is completely dry and brown (the toxin is usually dissipated within 72 hours).

- Do not allow access to wild cherry leaves. After storms or before turnout to a new pasture, always check for and remove fallen cherry tree limbs.
- If high cyanide is suspected in forages, do not feed as green chop. If cut for hay, allow to dry completely so the cyanide will volatilize before baling. Make sure hay is completely dry because toxicity can be retained in cool or moist weather. Delay feeding silage 6 to 8 weeks following ensiling.
- Forage species and varieties may be selected for low cyanide potential.
- Test any suspect forages before allowing animal access. A rapid field test is available that can provide on-site results. Contact your county Agricultural Extension Agent for further information.

See ID-220: *Cyanide Poisoning in Ruminants* at http://www2.ca.uky.edu/agc/pubs/ID/ID220/ID220.pdf.

Parasites/Worms

Internal Parasites

Internal parasites are present in most beef herds in Kentucky. The condition is often subclinical and results in hidden losses through reduced gain and feed efficiency in what appear to be healthy cattle. Cattle infected with a heavy load of internal parasites may show many of the following symptoms:

- Diarrhea
- Rough hair coat
- "Bottle jaw," or accumulation of fluid under the jaw
- Poor weight gain
- Unthriftiness

The life cycle of most intestinal and stomach worms works as follows. Mature female worms that live in the gut of animals produce a large number of eggs that pass out of the animal in the manure. The moisture and warmth of the manure pad helps the eggs hatch and develop into larvae. When they reach the infective stage, the larvae of most species move onto the forage where they are ingested by cattle. Once inside the animal, they grow to maturity, and the cycle begins again.

The medium brown stomach worm *(Ostertagia ostertagia)* is different in that the larvae may enter digestive glands in the stomach lining and become inhibited (hibernate) for as long as four months. This period of inactivity generally occurs in the summer and/or winter. The hibernation is a method of survival for the worms because the eggs are not deposited on hot, dry summer pastures or frozen ground where they would die quickly. However, when favorable weather resumes for development of worms on pasture, the larvae become active in the stomach lining. They grow much larger as they develop into adult worms and tear out of the glands, damaging them as they leave. They can emerge gradually or suddenly, causing much harm to the stomach (abomasal) lining.

Several products help control internal worms in cattle. They are in the forms of injectables, pour-ons, drenches, pastes, blocks, crumbles, and feed additives. Select the appropriate product based on management practices and veterinarian's recommendations. Dewormers used during the hot summer and cold winter should be labeled as effective against inhibited (hibernating) *Ostertagia ostertagia* larvae. Albendazole (Valbazen®), doramectin (Dectomax®), eprinomectin (Eprinex®, LongRange®), ivermectin (Ivomec®), moxidectin (Cydectin®), oxfendazole (Synanthic®), or a double dose (10 mg/kg) of fenbendazole (Safe-Guard®, Panacur®) removes the adult and inhibited Ostertagia (Table 7-10).

Most producers deworm their cattle when they have other working procedures scheduled. However, the traditional fall and spring working periods with pregnancy checking or cow-calf vaccination may not always be the best times to deworm as timing for deworming is dependent on the weather, grass growth, and pasture management.

Control of internal parasites should be accompanied by other measures, such as not overstocking pastures, pasture rotation, feed bunk management and sanitation, and an adequate level of nutrition.

Cattle Grubs

Cattle grubs are the immature or larval form of heel flies. These insects can cause losses in two ways. The first is in early summer when the bumble-bee like adult flies buzz around the lower legs of animals in order to glue their eggs to hairs. Cattle run with their tails up (sometimes called "gadding") to avoid the buzzing flight of these large insects. Cattle may injure themselves as they attempt to escape. The second, most obvious damage occurs the following spring when mature grub larvae emerge through nickel-sized

Table 7-10. Efficacy of common anthelmintics against internal parasites of cattle.[1]

Group	Drug	Product	Oster. Adult	Ostertagia Inhibited	Nematodes (Intestinal)	Lung worm	Tapeworm
Benzimidazole	Fenbendazole	Panacur/Safe-Guard	++++	+++	++++	++++	+++
	Oxfendazole	Synanthic	++++	+++	++++	++++	+++
	Albendzole	Valbazen	++++	+++	++++	++++	+++
Imidazole	Levamisole	Levasole, Tramisol	+++	+	++++	+++	-
Pyrimidine	Morantel tartrate	Rumatel	+++	-	++++	-	-
Avermectin	Ivermectin	Ivomec	++++	++++	++++	++++	-
	Eprinomectin	Eprinex, LongRange	++++	++++	++++	++++	-
	Doramectin	Dectomax	++++	++++	++++	++++	
Milbemycin	Moxidectin	Cydectin	++++	++++	++++	++++	-

[1] Adapted from *The Compendium*, April 1997.
+ = relative level of efficacy; - = not effective.

breathing holes cut in the skin along the back. Ultimately, the grub will squeeze out of the hole, drop to the ground to pupate, and emerge a few weeks later as an adult.

Small cattle grubs can be controlled with a systemic insecticide / dewormer applied between mid-July and the end of October. Products for control include pour-on products (Cydectin®, Dectomax®, Eprinex® and Ivomec®) and injectable dewormers (Dectomax® and Ivomec®). Treatments made too late (after November 1, the grub "cutoff date" in Kentucky) can kill large grubs migrating through tissues, producing an adverse reaction in cattle.

External Parasites

Attacks by biting flies, face flies and lice reduce beef producers' profits by lowering weight gains, reducing milk production, and in some cases transmitting pathogens. In addition, animals stressed by severe infestations may be more susceptible to diseases.

Flies

Cattle fly season begins in late spring and continues until early fall. The group includes horn flies, horse flies, and face flies.

Horn flies and horse flies are blood feeders. Horn flies stay on cattle almost continuously, leaving only when disturbed or to lay their eggs in fresh manure, their only breeding site. These flies sit on the shoulders, backs, and sides of cattle. Each one takes 20 to 30 small blood meals a day. Spring calves are most susceptible to attack. At the end of the summer, unprotected animals may be 12 to 20 pounds lighter than those on which horn flies are controlled. Losses occur when horn fly numbers exceed 100 per side.

Several species of horse flies can feed on pastured cattle. They breed in damp soil so problems are greatest around wet or wooded areas. It is difficult to protect animals from horse flies because they spend only a few minutes feeding. The flies are seldom on cattle long enough to be affected by an insecticide. Attempts of horse flies to feed are often interrupted because of their painful bite. These insects often have to visit several animals to get a complete meal; this increase the chances of them transferring blood-borne diseases such as anaplasmosis if there are infected animals in a herd or nearby.

Face flies have abrasive sponging mouthparts that they use to blot up tears from around an animal's eyes. Their feeding is very annoying; however, face flies also can spread the bacteria that cause pinkeye within a herd or to nearby herds. Face flies, which only breed in fresh cattle manure, only spend a few moments on animals and are easily disturbed. As with horse flies, this makes control difficult.

Insecticides can be applied to cattle by ear tags, dust bags, oilers, pour-ons, sprays, or in mineral or feed to treat manure. Each method has advantages and disadvantages. Insecticide-impregnated ear tags can provide excellent long term horn fly control and can suppress face fly numbers. In general, two ear tags per head gives better face fly protection than one. Apply tags in late May or early June when the horn fly population reaches 100 per side. Remove tags in September/October. Pour-ons or animals sprays give 2 to 3 weeks of protection and must be repeated as needed. Forced-use dust bags can keep the face treated to protect against face flies and also work well against horn flies. Follow directions for the application amount and timing and meat withdrawal time, and discard empty containers properly.

Horn flies can become resistant to some groups of insecticide if used for several consecutive years. The main groups are synthetic pyrethroids (P), organophosphates (OP), and abamectins. Alternate the insecticide type (P or OP) and/or methods of control to eliminate insecticide-resistant populations of flies.

Lice

Feeding and annoyance from biting and sucking lice can be costly. They can cause weight loss and general lack of thriftiness in cattle during the winter. Stress from heavy infestations can mean loss of body condition, increased susceptibility to or slow recovery from diseases, or just generally poor performance. Blood loss from feeding by large numbers of sucking lice can cause anemia. Biting lice use their chewing mouthparts to feed on dead skin, hair, and skin secretions. These very active lice irritate animals as they continually move over the skin to feed. The combined stress of lice with intestinal worms, or other conditions, can multiply losses.

Biting and sucking lice can spread quickly throughout a herd from a few infested animals. Infestations can result from new additions to the herd, cross fence mixing, or survival of lice over the summer on a few susceptible animals. Lice are most numerous, and usually present on more animals in the herd, during the winter. They thrive when temperatures are cold, cattle have longer coats, and their skin is less oily. Inadequate nutrition, compromised immune response, and shorter day lengths also can favor lice buildups.

Excessive rubbing, loss of hair clumps, and raw spots from constant grooming or scratching can mean lice. However, other possible causes include ringworm, dietary deficiencies, or mange. Careful examination of symptomatic animals for nits (louse eggs attached to hairs) or lice will help to diagnose infestations.

Lice can be controlled in the winter with pour-on or spot-on insecticides. Do not use systemic dewormers on cattle that were not treated in the fall for cattle grubs or if their treatment history is not known because these can cause adverse reactions if grubs are migrating in animals. Treat all animals in the herd for lice to prevent reinfestation from untreated cattle. Apply a second treatment 14 to 21 days later to kill lice that have hatched from eggs after the first application.

Administering Drugs to Cattle

No matter which method used to administer drugs, always use proper animal restraint to do a good job. Since most drugs are relatively expensive, take time to do the job right. If administration technique is sloppy, the biggest loss will be lack of response to the drug.

Injections are probably the most common method of administering drugs. Drugs that are injected act rapidly, are used efficiently, and may act longer than those given orally or applied topically. For the best results, take care to properly prepare the injection site, equipment, and product.

There are three types of hypodermic syringes: plastic disposable, metal pistol-grip reusable, and plastic pistol-grip disposable. Be sure to keep extras in case of breakage or malfunction. Convenient sizes to have available are 5, 10, and 20 cc. [*Note:* Milliliter (ml) and cubic centimeter (cc) are the same volume; that is, 1 ml =1

cc.] Larger sizes (for example 60 cc) can be used in administering large doses or for multiple doses (similar to pistol-grip syringes). When loading the syringe, pull back the plunger and fill with an amount of air equal to the drug to be put in the syringe. Inject the air into the bottle and withdraw the drug. Hypodermic needles also come in many lengths and sizes; remember that the diameter becomes smaller as the gauge number gets larger (for example, 14-gauge is larger in diameter than 22-gauge). Consider both length and gauge when you prepare to give various types of injections. Generally, 16- and 18-gauge needles are required for most injections. Smaller-diameter needles may not allow thick liquids to flow easily and may bend. Larger diameter needles make a large hole and may allow the product to flow back out. Needles are available with plastic or aluminum hubs; aluminum hubs are recommended for cattle because they do not easily break.

Dart guns used to administer medications to sick cattle in the pasture have become increasingly popular in the past few years. It is often easier, faster and less stressful to medicate an animal with a dart rather than having to get it up from a remote field to work through the chute. However, there are associated risks with remote drug delivery (RDD) to animal health, animal welfare, human safety, and the safety and quality of the food products produced from dart-treated animals. In situations where darts are used, producers should still comply with the National BQA Guidelines for injections including using the correct route of administration, needle selection, medication selection and volume, as well as meeting all record keeping requirements to properly observe withdrawal times.

Types of Injections

The most commonly used types of injections are subcutaneous (SQ), intramuscular (IM), and intravenous (IV).

Subcutaneous Injections

Subcutaneous injections (SQ) are made just under the skin but not into the muscle tissue. The side of the neck is the area to make injections in cattle. To properly administer the injection, lift the skin with your free hand, and insert the needle into the raised fold of skin at the base of the tent (Figure 7-2). Needles of 16- to 18-gauge and 5/8- to 1-inch are usually used. Do not give more than 10 cc at a single injection site. Separate injection sites by at least 5 inches. SQ is always the preferred route to use when a product can be given either SQ or IM.

A few new vaccines are now available in a pellet form delivered subcutaneously. Each pelleted implant dose contains a combination of immediate release (IR) and programmed release (PR) antigen pellets, and includes the antigen equivalent of two doses of vaccine but administered at one time.

Intramuscular Injections

Intramuscular (IM) injections are made directly into muscle tissue, generally with a 1- to 1½-inch needle. Do not inject more than 10 cc at an injection site. Too much drug in one area can cause muscle damage and reduce uptake. IM injections should be given in the triangle area in the neck. Recent beef audits indicate that injections should be made about 3 inches in front of the shoulder blade to avoid the infraspinatus (flatiron) muscle. Never make injections in the rump (see figures 7-3 and 7-4 for proper injection sites).

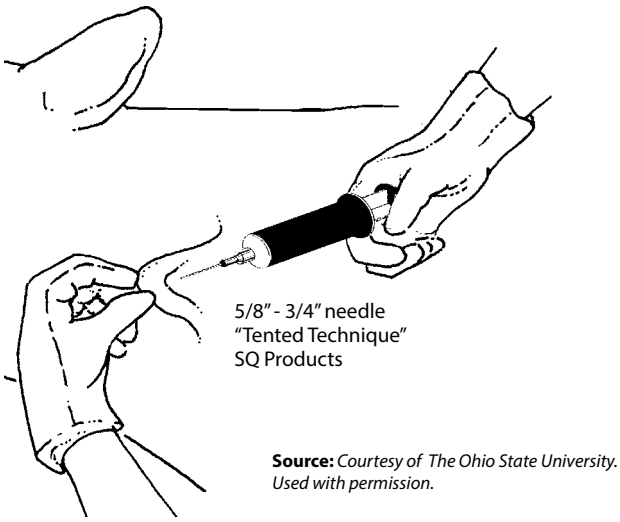


Figure 7-2. Proper subcutaneous (SQ) injection technique.

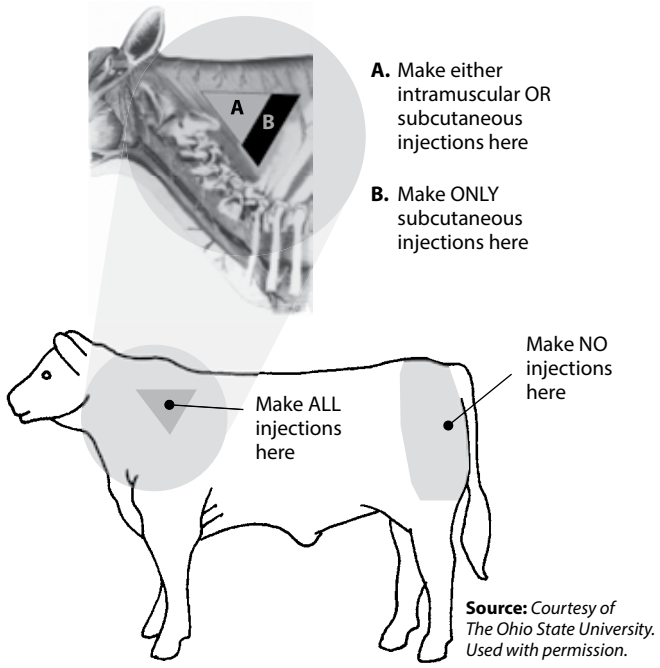


Figure 7-3. Proper injection sites.

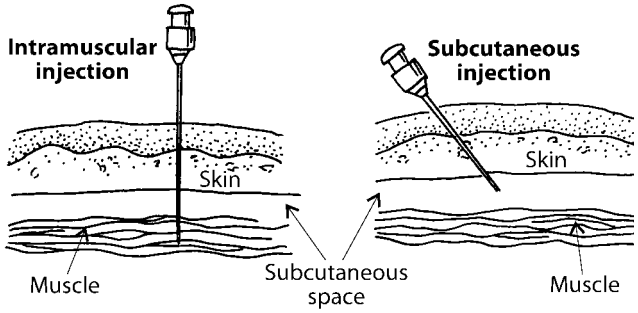


Figure 7-4. Illustration of intramuscular or subcutaneous injections.

Intravenous Injections

Intravenous injections (IV) are useful when a large volume must be given (for example, when treating milk fever or grass tetany), when the drug must not be deposited outside the vein, or when rapid treatment is necessary. These injections are made directly into a blood vessel, usually the jugular vein. Because some knowledge of anatomy and experience is needed, intravenous injections should be performed only by an experienced person following recommendations and instructions by a veterinarian.

An injection site can be found on the side of the animal's neck by placing the thumb or forefinger of your free hand firmly onto the area where the jugular vein is located. The vein should bulge between your thumb and the animal's head so that it can be seen and felt. The needle must be sharp and inserted with a quick thrust to hit the vein. Do not stick the needle in until you can see the vein.

Intranasal Administration

Intranasal refers to inside the nostril; drugs administered intranasally (such as the intranasal IBR/PI-3 vaccines) are "squirted" inside the nostril using a special plastic applicator tip. Only a small amount of the product needs to come in contact with the mucous membranes to cause the animal to develop immunity. Expect a small amount of vaccine to flow out of the nostril after administration. Intranasal vaccines do not have a long duration of immunity (average is approximately 1-2 months of coverage).

Precautions

When using injectable drugs:

- Never exceed the recommended volume per injection site. This could cause:
  - » Tissue damage, soreness
  - » Extended withdrawal times due to altered absorption
  - » Increased possibility of "leakage" of the product
- Never use a needle on an animal and then insert it back into the bottle. Have a clean needle to use in the bottle for withdrawing the drug.
- Always take plenty of time, handle drugs properly, and make injections correctly.

Adverse reactions (anaphylactic shock or allergic) can occur, especially to "Gram negative" bacterial vaccines (examples: *E. coli, Histophilus somni,* leptospirosis, pinkeye, Pasteurella/Mannheimia, and Vibrio). These are more likely to occur during hot weather or when given at the same time as a vitamin A and D injection. Epinephrine (available by prescription only) should always be available to treat cases in an emergency.

Administering Drugs Orally

Another method to administer drugs is orally. In this case, the product is either fed to a group of animals or given directly to an individual animal through the mouth. Balling guns are used to give boluses, capsules, and tablets. Drenching equipment is used to give liquid to cattle. Feeding of drugs requires that all animals eat an adequate amount to be effective. Therefore, the product must be palatable, and adequate feeding space must be allowed so that all animals eat the proper amount in the required time. The use of medically important antimicrobials in feed is under veterinary oversight. This was accomplished by changing previously labeled over-the counter (OTC) drugs used in feeds to Veterinary Feed Directive (VFD) drugs. VFD drugs are defined by FDA as "drugs intended for use in or on animal feed which are limited to use under the professional supervision of a licensed veterinarian". This means for a producer to obtain a feed or mineral containing a VFD drug (for example-chlortetracycline in medicated mineral), a veterinarian must write a VFD order (similar to a prescription) for the feed mill to fill according to the drug label.

Beef Quality Assurance Issues

- **Injection technique:** Use 5/8-inch or 3/4-inch 16- or 18-gauge needles for subcutaneous injections (SQ). For IM injections, use 16- or 18-gauge needles 1-inch long for calves and 1.5 inches for cows. Make sure needles are sharp, and discard in an appropriate container when needles become dull, bent, or burred. All injections should be in front of the shoulder blade. Follow label directions carefully and consult a veterinarian if in doubt. Always use SQ products when available. Do not inject more than 10 ml (cc) of an antibiotic in one site.
- **Injection equipment:** Disposable syringes and needles are recommended. Any disinfectants, including alcohol, should not be used as they will neutralize vaccines (especially modified-live) and will chemically react with some antibiotics.
- **Drug residue avoidance:** Observe label directions and withdrawal times carefully. If dosages are increased (extra-label drug use), withdrawal times are significantly increased as well. When using drugs in any manner differently than stated on the label, this must be under the order of a licensed veterinarian. Never use a veterinary drug in an extra-label manner without consulting a veterinarian. Doing this without direction by a licensed veterinarian is illegal. Some drugs (chloramphenicol, diethylstilbesterol, clenbuterol, furacin spray, and others) are illegal and cannot be used in food animals with no exceptions.
- **Drug and vaccine storage: Store vaccines under refrigeration as soon as purchased.** Note the expiration date and discard outdated and leftover product. Use a transfer needle to reconstitute vaccines.
- **Records:** Careful records should be kept for all treatments and vaccinations. The records should include the group of cattle vaccinated, date, product used, dosage, route of administration, injection area, and withdrawal date.

See the publication, ID-140: *Kentucky Beef Quality Assurance Program* at http://www2.ca.uky.edu/agcomm/pubs/id/id140/id140.pdf for more specific information.

Biosecurity Protection

Biosecurity management practices are designed to reduce or prevent the spread and movement of infectious diseases on to an operation and among the cattle. Biosecurity can be very difficult to maintain because the interrelationship between management, biologic organisms, and vectors (dogs, cats, rodents, biting flies, birds, wildlife, etc.) is complex. Although developing and maintaining biosecurity may be difficult, it is the most effective means of disease control available. No disease prevention program will work without it.

A biosecurity plan has three major components: traffic control, isolation, and sanitation.

Traffic Control

To protect the food supply, many feedlots, meat packers, and food processors have restricted access to their facilities and increased security. Livestock producers should consider restricting access to their property and remain vigilant to protect the nation's food supply. Check livestock regularly, and immediately report signs of disease or anything out of the ordinary to a veterinarian. The following signs that could be symptoms of different, serious diseases:

- Sudden, unexplained death loss in the herd
- Severe illness affecting a high percentage of animals
- Blisters appearing around an animal's mouth, nose, teats, or hooves
- Large numbers of animals suddenly going off feed

Isolation/Quarantine

Isolation prevents contact between animals within a controlled environment. The most important step in disease control is to minimize commingling and movement of cattle. This includes isolation of new purchases for at least two weeks and preferably four if possible. Isolate sick cattle and return them to their original group when they have recovered.

Sanitation

Good sanitation reduces exposure to infectious agents. Do not use instruments and equipment on healthy animals following their use on sick or infected animals without thorough disinfection. Be aware when working sick animals, and try to work healthy animals prior to sick animals if possible. Rodents and other wildlife are capable of carrying diseases within a herd. Keep feeding areas clean, and keep feed in enclosed bins or containers to reduce contamination. Place dead animals in a location that allows rendering trucks access without coming into contact with healthy cattle.

Minimum Biosecurity Measures

- Maintain a visitor book. Visitors should avoid livestock areas, pens, and barns unless it is necessary. Allow no entry to your farm if visitors have been exposed to the foot and mouth disease virus (or any foreign animal disease) within the past five days.
- Offer boots to all visitors. Disinfect shoes or boots on arrival if disposable boots are not used. Wear clean, disinfected boots when visiting other farms and stockyards.
- Isolate all new animal additions by at least 300 yards from your herd for 14-21 days. Test and/or vaccinate before they enter the herd.
- Remove and promptly dispose of dead animals (have removed, bury, or compost).
- Report all suspicious activity and events to local authorities.
- Control rodents and wildlife, especially in the feed areas.

Identification of Cattle

Animal identification is important in beef cattle herds for effective record keeping, performance testing, and artificial insemination, as well as routine observations. The three most common methods of identification are ear tagging, tattooing, and branding.

Regardless of the method used, a numbering scheme must be decided on for meaningful records. Each animal should have a unique number. Herd size determines how many digits are necessary, but each digit should have some meaning.

In a four-character number, this is a common scheme: the first number or letter denotes the year of birth; the second character identifies the sire or breed crossed; and the last two numbers are the order of birth. Or a letter can be used to denote the year of birth using the international year/letter designation (see Table 7-11).

For example, the tattoo "5 2 14," read from the left, could be:

5 = 2005 birth year
2 = sire No. 2
14 =14th calf born in 2005

Or the calf could be tattooed R214 and have the same meaning.

Ear Tagging

Ear tagging is probably the most common method of identification. It is not permanent because tags are frequently lost. Ear tags are best used in combination with a permanent form of identification, such as a tattoo or brand. Pre-numbered tags are available or, if numbering, be sure to use ink that will bond to the tag, and allow adequate time for it to dry.

Table 7-11. International year/letter designations.

Year	Letter	Year	Letter*
2014	B	2021	J
2015	C	2022	K
2016	D	2023	L
2017	E	2024	M
2018	F	2025	N
2019	G	2026	P
2020	H	2027	R

* This system skips the letters I, O, Q, and V.

Step-by-step procedure for ear tagging:

1. Select the tag and numbering system to be used.
2. Number plastic ear tags with a marking fluid or ink that bonds to the ear tag.
3. Insert the ear tag into the appropriate applicator. When two-part tags are used, be sure they line up correctly and that you are using the correct pin in the tagger for the type of tag.
4. Select the tagging site on the ear. Place one-piece plastic tags between the cartilage ribs, approximately one-half the distance from the base to the tip of the ear. You may place two-piece tags between the cartilage ribs or below the ribs. Place metal tags into the top of the ear near the ear's base.
5. Insert the ear tag. Apply the two-part tag with the plier-type applicator by squeezing the handles until the ear tag snaps together. Metal types are applied in the same manner. The knife-like applicators (for one-piece tags) are forced through the ear using extreme care. Be sure the knife is turned so that the tag hangs straight down or at an angle away from the base of the ear.
6. Keep instruments clean and disinfected to prevent infection.

Tattooing

Tattooing is a permanent means of identification, but it cannot be read from a distance.

Most purebred organizations require that animals be tattooed in one or both ears before registration. The tattooing

Table 7-12. Growth-promoting implant products available for utilization in beef cattle.

Product Name	Suckling Calves	Weight Restriction	Age Restriction	Grazing	Steers	Heifers	Replace-ment Heifers	Back-grounding Confined	Feedlot Confined	Approx. Effective Days
Ralgro	X		> 30 d	X	X	X	X	X	X	70-100
Revalor H						X		X	X	100-140
Revalor S					X			X	X	100-140
Revalor G				X	X	X		X	X	100-140
Revalor IS					X			X	X	100-140
Revalor IH						X		X	X	100-140
Revalor 200					X	X			X	100-140
Revalor XS					X				X	200
Revalor XH						X			X	200
Finaplix-H			63 d preharvest			X			X	60-100
Synovex S		> 400			X			X	X	80-120
Synovex H		> 400				X		X	X	80-120
Synovex C	X	< 400 Suckling	> 45 d	X	X	X	X	X	X	100-120
Synovex Choice					X	X			X	100-140
Synovex Plus					X	X			X	100-140
Synovex One Feedlot					X	X			x	200
Synovex One Grass					X	X		X	x	200
Component E-C w/Tylan	X	< 400 Suckling	> 45 d	X	X	X	X	X	X	100-140
Component E-H w/Tylan		> 400				X		X	X	120
Component TE-IH w/Tylan						X			X	120
Component TE-H w/Tylan						X			X	120
Component E-S w/Tylan		> 400			X			X	X	100-140
Component TE-IS w/Tylan					X				X	120
Component TE-S w/Tylan					X				X	80-90
Component TE-200 w/Tylan					X	X			X	80-90
Component TE-G w/Tylan				X	X	X		X	X	100-140
Compudose	X Steers			X Steers	X	X		X	X	170-200
Encore	X Steers			X Steers	X	X		X Steers	X	400

Note: Information summarized from product labels. Please read and follow label recommendations when using these and any other products.

instrument consists of a pliers-type device with numbers and/or letters. These numbers or letters are made of needle-like projections that pierce into the ear when the handles of the tattoo instrument are squeezed together. An indelible ink is then rubbed into the small punctures. After healing, the tattoo is permanent.

Step-by-step procedure for tattooing:

1. Restrain the animal.
2. Locate the area of the ear to tattoo. Two ribs of cartilage divide the ear into top, middle, and lower thirds. Place the tattoo in the top of the ear just above the cartilage rib. It is generally best not to tattoo between the two cartilage ribs as this area is frequently used for ear tags. Also, the area between the two ribs on the right ear of heifers is reserved for Brucellosis vaccination tattoos.
3. Clean the inside of the ear where the tattoo is to be placed with a cloth soaked in alcohol.
4. Position the tattooing instrument so that the numbers are in the proper position. Squeeze the handles together completely and quickly.
5. Rub tattoo ink into all needle marks. Apply the ink with a roll-on applicator, or rub it in with the thumb or an old toothbrush.

Freeze Branding

Brands used for individual animal identification usually consist of three or four numbers. The most common location of brands is the hip. Brands can be applied easily to these locations when animals are restrained in a squeeze chute. Each character is generally 3 or 4 inches high. Numbers that are 3 inches are generally used on young cattle; 4-inch numbers are used on mature cattle.

Freeze-branding of cattle with super-chilled irons (copper or copper alloy) is considered more humane than hot-branding, with less damage to the hide. When applied properly, the cold brand destroys the color-producing cells in the hide, and the hair grows out white. The visibility of these brands is much better on black or dark-colored cattle and not as good on white or light-colored cattle.

Freeze branding frequently gives inconsistent results, especially when using liquid nitrogen as the coolant. Liquid nitrogen is readily available, but dry ice and alcohol give more consistent results. The most critical steps are: (1) using dry ice and alcohol, (2) allowing adequate time for the irons to chill prior to use, (3) allowing adequate time for irons to re-chill after each application,

(4) using a liberal amount of alcohol on the brand site, (5) proper application time, and (6) not branding on a rainy day (or windy day, if possible).

If the following steps are carefully applied, the brands should be very legible. Brands should appear in about two months.

- Line up supplies ahead of time:
  - » Dry ice (50 hd. = 50 lb. ice and 2½ gal. of alcohol)
  - » Alcohol (denatured, 95 to 99%)
  - » Styrofoam cooler(s)
  - » Spray or squirt bottles
  - » Clippers, extra blades (these do not have to be surgical)
  - » Brush
  - » Time clock
  - » Branding irons (copper)
- Put irons in Styrofoam cooler(s), cover the head of the irons with alcohol, then add chunks of dry ice.
- Wait until frost creeps up the shaft of the iron (around 10 minutes).
- Put cattle in the chute.
- Brush and clip the brand site.
- Saturate the brand site with alcohol.
- Apply branding iron firmly for 45 seconds. Tap the fresh brand with your fingernail; it should feel as if you are pecking on wood or pipe.
- Return iron to the cooler. Do not reuse an iron until the iron has been re-chilled for at least a minute.
- Put alcohol on brand site again before doing the next number/letter. Then repeat branding.

The calf usually jumps and squirms for the first 10 seconds after the brander is applied to the hide. The reason for this is that the extreme cold activates the nerve endings. After about 10 seconds, the nerve endings are frozen and inactivated, and the animal usually stops moving. You should be ready for this and keep the brander in the same position the entire time to ensure a good, clear freeze brand.

Branding is used for two basic reasons: to establish ownership of an animal and to identify an individual animal. Like many states, Kentucky registers ownership brands through the Department of Agriculture. The use of a registered ownership brand discourages cattle rustling and serves as the cattle owner's trademark.

Implants for Beef Calves

Utilization of growth-promoting implants in the beef cattle industry provides an opportunity for improving production efficiency. These products have been extensively studied for safety and efficacy. Growth-promoting implants promote protein synthesis, resulting in a 10% to 30% increase in growth along with a 5% to 10% improvement in feed efficiency. These products mimic naturally occurring compounds produced by the animal. There is no meat withdrawal time for any implants.

There are a number of growth-promoting implant products available on the market (Table 7-12). Products are often categorized based upon type of compound contained and whether or not it is in combination with a testosterone or equivalent product. Table 7-12 contains a listing of available products, compounds, and concentrations as well as projected payout period. When choosing a product, consider the sex of the animal to be implanted and the duration of ownership. Always read the label before using the product to ensure the appropriate use. To date, no implants are approved for use in calves intended for the production of veal. As a general recommendation, male calves should be implanted when they are castrated. Do not implant bull calves that you intend to save for breeding. The more aggressive the implanting program (higher potency, i.e., suckling calf < stocker cattle < feedlot), the greater the effect is on carcass marbling score and carcass maturity. As the implanting program becomes more aggressive, seeking to increase liveweight gain and feed efficiency in the feedyard, marbling score decreases. As marbling score decreases, quality grade will also decrease. Two important considerations for deciding which implant program to use in the feedyard are how cattle are to be sold (on the rail based on carcass grade and yield or live on pen average) and the spread between Select and Choice.

Step-by-step procedure for administering implants:

1. Properly restrain the animal. When implanting, head restraint is most important for proper implant placement. Implant cradles or nose bars on chutes greatly aid in limiting head movement.
2. Determine which ear to implant, and adjust the implant instrument so the needle can be positioned next to and parallel to the ear, with the slant side of the needle facing outward. Implant all calves in the same ear.
3. Select the proper implant site on the back of the ear. The implant will be placed between the skin and cartilage in the middle third of the ear.
4. Clean the needle and implant site with disinfectant to reduce contamination of the needle wound; lay the implant gun on a paint tray so that the needle will rest on a sponge with disinfectant solution (diluted chlorhexidine mixed at recommended dilution rate).
5. Cattle that have manure- and/or dirt-covered ears should have the back of the ear lightly scrubbed with a brush and disinfectant. Wipe the back of the ear dry with a clean paper towel or cloth before inserting the needle to reduce the risk of introducing foreign material and pathogens.
6. Grasp the ear with one hand while the other hand positions the instrument parallel to and nearly flush with the ear. Put the point of the needle against the ear with the beveled part facing up.
7. Use the tip of the needle to prick the skin, lift slightly, and completely insert the needle under the skin. Little resistance should be felt as the needle slides under the skin. Moderate resistance or too steep of an angle likely means the needle is going into the cartilage of the ear and not the preferred location. When inserting the needle, avoid piercing the large ear veins.
8. Do not crush the implant while administering it. To avoid crushing implants, slowly retract the needle as pressure is applied to the trigger if the gun does not have a self-retracting needle. Crushed or improperly administered implants can increase the risk to riding activity or "bulling."
9. Depress the plunger of the implant gun, and withdraw the needle with the plunger still depressed.
10. Feel the ear to ensure that the implant has been deposited in the proper location. Improperly placed implants reduce your return on your investment. Never sacrifice implant technique for speed.

For more information, see ASC-25: *Growth-Promoting Implants for Beef Cattle* at http://www2.ca.uky.edu/agc/pubs/asc/asc25/asc25.pdf.

Precautions

Common implant administration mistakes include:

- Implant is improperly placed. Do not allow the needle to gouge or pierce through the cartilage. If resistance is felt when inserting the needle, it is quite probable that the cartilage has been gouged, and pellets may be covered with scar tissue and "walled off," resulting in poor drug absorption and decreased expected gain.
- Needle pierces through the other side of the ear due to the needle angle being too steep at entry.
- Poor sanitation results in an abscess.
- Implant is crushed or misaligned.
- All implants come with instructions for implanting and proper handling. Review all instructions carefully before implanting.

Castration of Bull Calves

Castration is the removal or destruction of the testicles of a bull by surgical or nonsurgical methods. The castrated male calf is then referred to as a steer. Steers are preferred in the marketplace and bring more per pound than bull calves because they have a better disposition and their meat is preferred over that from bulls. Implanted steer calves weigh as much at weaning as bull calves.

Bull calves should be castrated as soon after birth as possible. It is best to allow time for the calf to nurse and to bond with the dam before doing any procedures. In some herds, it is not easy or practical to castrate early because herd sire prospects will not be selected until weaning. However, older and heavier bulls generally bleed more and gain weight much more slowly after castration.

- **Do** castrate/dehorn as young as possible.
- **Do** castrate/dehorn in cool weather to avoid flies and heat stress.
- **Do not** castrate/dehorn in extremely hot weather.
- **Do not** castrate/dehorn at weaning because the procedure increases stress at an already stressful time.
- **Do** keep calves in a clean environment after castration because of increased chance of infection.

There are several methods of castration. All of the methods accomplish successful removal of the testicles if done properly; seek professional advice from a veterinarian before attempting any of the procedures described below.

Knife castration is the most common method used. Two variations are generally used: cutting off the lower third of the scrotum or slitting down both sides of the scrotum. A scalpel blade works well for making the incision. However, specially designed castration knives are available, such as the Newberry® knife, which cuts on both sides of the scrotum at once.

Make castration the last step in processing the calf. When the calves are released from the chute, they should be able to go to a clean, dry area to lie down. Clean hands help to prevent introducing infection. Stretch the scrotum tightly and cut off the bottom one-third of the scrotum or use a Newberry knife to cut down the sides of the scrotum to gain access to the testicles. Frequently after the scrotum is opened, the testicles will be drawn up high into the neck of the scrotum. To find the spermatic cords, one testicle can be held and pulled down while the scrotum is pushed up with the other hand. A second technique is referred to as "milking." Both testicles are held, and one is pushed forward (not upward) while the other is pulled back. Reverse the process until some of the tissue holding the spermatic cords is broken down. Do not place hands inside the scrotum as this can lead to infection. Sever the spermatic cord as high as possible by physically pulling, scraping with the knife blade, using an emasculator that crushes as it cuts, or using a Henderson castrating tool with a standard 3/8-inch variable-speed cordless drill. Once both testicles are removed, apply an effective fly repellent if needed.

The bloodless emasculatome (Burdizzo®) is one method of nonsurgical castration for use in a muddy or wet environment. It can be used at any time of year without concern for an open wound. "Clamped" bull calves frequently become stags (exhibiting some of the physical characteristics of a bull) if the procedure is not properly executed. Clamping is best accomplished with the calf standing and a tail-hold applied (grasp the tail near the base and bend it sharply upward and over the back toward the calf's head). Be sure the emasculatome closes properly. Each cord should be crushed separately. Position one cord against the outside of the scrotum then clamp approximately 2 inches above the testicle. It is good practice to clamp each cord twice. Repeat the procedure on the other cord, making sure to leave the middle (septum) unclamped for adequate circulation to the scrotum. If you clamp all the way across (including the septum), the scrotum can slough off and expose the testicles. The crushing of the cord should make the testicle atrophy and become nonfunctional.

Several other methods are available for nonsurgical or bloodless castration. Elastrator bands are applied to the neck of the scrotum above the testicles at as young an age as possible. The elastrator band is placed on the instrument and opened. Both testicles must be drawn down through the open band and held there while the band is released. The band is closed on the neck of the scrotum. This cuts off blood circulation to the testicles and scrotum. The tissue dies, dries up, and eventually drops off. There are several potential problems with this method. It is easy to leave a testicle in the body cavity or not place the band high enough so that male hormones are still being produced, resulting in stag behavior and decreased carcass value when finished. Tetanus may occur, so a tetanus toxoid vaccine should be given in advance of castration or tetanus antitoxin when applying the band. When the bands are old or have been improperly stored, they may not be effective in cutting off the circulation.

Additional bloodless methods involve using the Callicrate Bander™, California Bander® or EZE bloodless castrator. These items are similar and have their best use on older, larger bulls. All three methods use elastic tubing that is drawn very tightly around the scrotum above the testicles. When using the EZE castrator or the California Bander, a metal clip is placed on the tubing to pinch it off and hold it in place after drawing tight. The Callicrate Bander uses preformed loops of solid core tubing with the clips attached. The testicles are placed through the open tubing, and it is ratcheted tight

against the scrotum. The entire scrotum will usually fall off in three to four weeks. Complications with these methods include tetanus and the possibility of a large infected, painful, scrotum if the tubing is not drawn tightly enough. Tetanus toxoid vaccine should be given before or tetanus antitoxin at the time of castration (consult a veterinarian for clarification) when using any of these instruments.

Remember, castration should be done as early as possible in the calf's life. This will create less stress on the calf and reduce the possibility of complications.

Estimating Age of Cattle by Their Teeth

Decisions on purchasing or culling commercial cattle are easier when age is known. However, if unknown how old an animal is, it is sometimes possible to estimate its age by appearance of the teeth.

Only the front teeth (incisors) are important in calculating age (cattle have no upper incisors—see Figure 7-5). The eight incisors (four pairs) on the lower jaw appear at different times and exhibit varying degrees of wear depending on age, genetics, and diet. By the time a calf is about a month old, it has eight temporary incisors. These temporary teeth are shed and replaced by permanent teeth, in pairs. The first pair is the two central incisors in front. The second pair is the two teeth on either side of them, and so on for the third and fourth pairs.

At 18 to 20 months of age, the first permanent incisor tooth appears. By 25-26 months, the center incisors are fully erupted and in line. The following pattern of growth and wear appears at two years of age and above:

- 2 years: The central permanent incisors attain full development.
- 2½ years: The second set of incisors is cut. They are fully developed by age 3. The U.S. Food Safety and Inspection Service (FSIS) will call a calf 30 months of age if the second set has erupted.
- 3-3½ years: The third set of incisors is cut. They are fully developed and begin to wear at age 4.
- 3.5-4 years: The fourth set (corner teeth) is replaced. By age 5, they are fully developed.

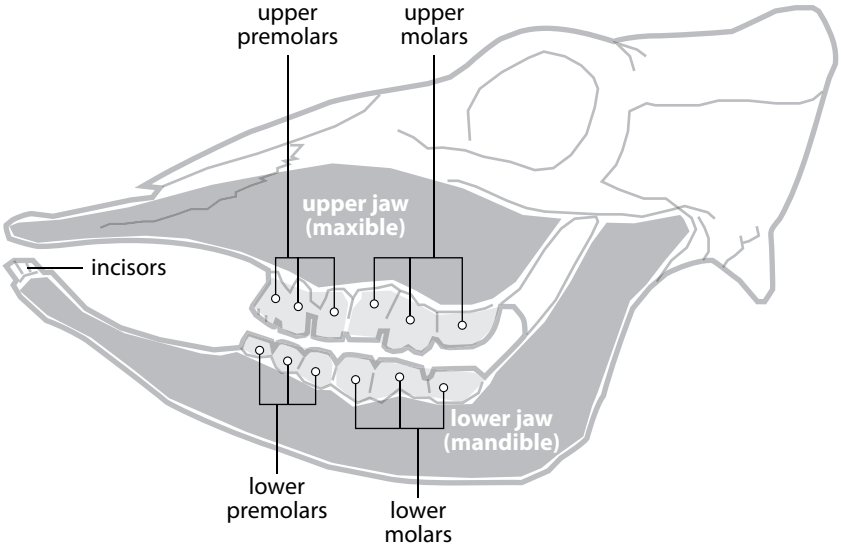
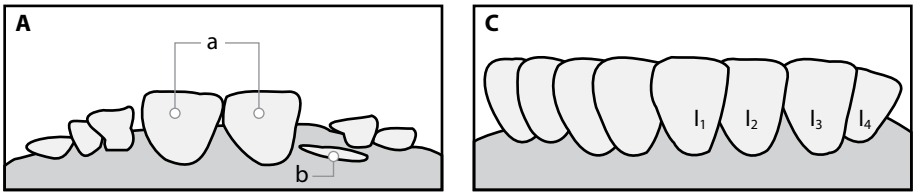


Figure 7-5. Cattle have no upper incisors, only lower.

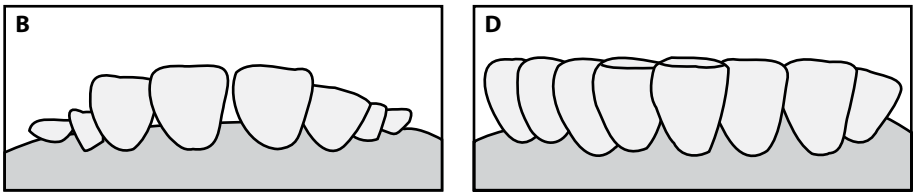
Age determination past 4½ years is less accurate and is mainly related to wear on the surface of the eight incisor teeth. The amount of wear also depends on the diet of the animal. Generally, the center pair begins to show wear at age 5, the second pair at age 6, the third pair at age 7, and the corners at age 8. The teeth begin to take on a "pegged" appearance at age 8-9 years; that is, the gum begins to recede from the base of the teeth. If looking at the teeth from above ("dorsally"), the teeth appear round and have lost the "spatula" or scoop shape. By the tenth to twelfth year, the teeth show progressive wearing to stubs. The animal may then become "smooth-mouthed," when the teeth are worn to the gums, or "broken-mouthed," when some teeth are lost. The food safety inspection service (FSIS) branch of USDA published an excellent guide to using dentition (teeth) to age cattle under the bovine spongiform encephalopathy (BSE or "mad cow disease") information tab. The link to the publication is: https://www.fsis.usda.gov/OFO/TSC/bse_information.htm.

Figure 7-6.



a. Permanent incisors. b. Erupting third permanent incisor, top of tooth **not** above gum line, animal less than 30 months of age.

Full set of permanent incisors, animal over 48 months of age.



Two sets of permanent incisors (with top corners of the second set above the gum line), animal 30 months of age or older.

Age 72 months, central incisors showing wear and leveled tops.

Adapted from *Guidelines For Age Verification In Cattle,* Hernan Ortegon, Alberta Agriculture and Rural Development, 2013

Dehorning Calves

Buyers of feeder calves prefer calves without horns. Dehorning reduces the possibility of injury and bruising of animals. Hornless cattle require less space at the feed bunk and in transit. Horned animals are more difficult to catch in a headgate and more likely to injure the handler or other cattle during processing.

It is best to dehorn animals as early as possible to minimize stress, preferably at less than two months of age. As calves get older, the process causes more trauma, more bleeding, and an increased chance of infection. When calves have matured enough to have a "horn" sinus, cutting the horn out leaves an open hole into the sinuses of the head. It is best to dehorn early when little or no cutting is required. It is also recommended not to dehorn cattle by a method requiring cutting during either the fly season or extremely cold weather. Maggots can be a problem during hot weather, and the exposed sinuses can lead to respiratory problems during extremely cold weather.

Calves can be dehorned genetically with the use of polled animals in the breeding herd. If calves are born with horns, however, dehorn them as early and humanely as possible, using one of the following methods along with local anesthesia to numb the site.

Spoon, or tube dehorning works on horn buttons or small horns just emerging. These tools separate the horn from the adjoining tissue with very little bleeding. Clean the area around the horn with a disinfectant. The cut should be made around the base of the horn to include about ⅛ inch of skin and should be about ¼ to ½ inch deep. After removing the horn, apply an antiseptic and insect repellent if needed.

An electric dehorner is an excellent tool for removing horns from calves of any age when the horn is still small. Most electric dehorners have cupped ends of different sizes that are placed over the horn. Select the "cup" that fits best over the base of the horn, and hold it on long enough to destroy the ring of growth cells around the base of the horn. The skin will look copper- or bronze-colored when completed. The horn or button can then be knocked off with the hot iron, or it will drop off in a few weeks.

Barnes-type dehorners may be necessary if dehorning is delayed until weaning. The instrument should fit over the horn and include a ring of skin and hair. The dehorners are available in calf and yearling sizes. The older the calf, the greater the potential for complications with this method. Close the handles to fit the blades around the base of the horn. To remove the horn, spread the Barnes handles open and twist while applying considerable pressure. A hot iron (electric dehorner) may be used to cauterize small blood vessels. Treat the wound with an antiseptic spray, and fly repellent if needed. Do not use blood-clotting powders if there are openings into the sinus cavity. Place a thin layer of cotton over the exposed cavity to keep out foreign particles, such as dust.

Feeding the Beef Herd

Jeff Lehmkuhler and Katie VanValin

Feed is the greatest variable cost of maintaining the beef herd. The nutrient requirements of the cow need to be met to maximize fertility and optimize reproductive success, improve weaning percentage and weights of calves at weaning. Meeting the nutritional needs of the beef cow herd is priority one in maintaining an efficient cow herd. To ensure economic efficiency, the cows' nutritional needs must be met cost-effectively. However, the cost of supplying an adequate diet to the cow is second to meeting the nutrient needs which means cheapest is not always best.

Beef cattle belong to a class of animals known as ruminants. Ruminants have a stomach that is compartmentalized into four sections. The largest compartment is known as the rumen. The rumen provides an environment for a vast number of microorganisms (bacteria, protozoa, and fungi) to flourish. These microbes essentially result in the rumen being a fermentation chamber. The feed/forage consumed is the substrate to support the growth of the microbes. The large capacity of the rumen allows for consumption and storage of a vast quantity of forage and feedstuffs. Rumen microbes provide the animal with cellulase, an enzyme not produced by mammals, to breakdown and utilize the forages they consume as well as the ability to incorporate non-protein nitrogen into amino acids. The end products of fermentation provide most of the energy absorbed and utilized by the cow. These microbes, as they are passed out of the rumen and digested, are also a primary protein source for cattle receiving a forage-based diet. In order for the microbes to efficiently breakdown the feeds consumed, supplements are often necessary to balance nutrients from the forage. Supplements also provide additional nutrients to the animal to achieve the desired level of performance.

Essential Nutrients

Nutrients are essential for animal maintenance, growth, reproduction, and milk production. Nutrients fall into the following classes: water, fat, carbohydrates, protein, minerals, and vitamins.

Water

Water is the most essential nutrient for animal life. Because of the abundance of water, it is often overlooked as an essential nutrient. The moisture content of the rumen is approximately 80% and allows for the microbes to associate with the feed consumed. Water consumption is vital for feed intake and therefore greatly influences performance.

Restricting water intakes leads to a direct reduction of feed intake (Table 8-1). For backgrounding cattle fed rations allowing average daily gains (ADG) of 2 pounds, a 4.5% decrease in feed would reduce gain by approximately 0.15 pounds daily. A 22% decrease in feed intake would result in a decrease of 0.75 pounds daily.

Stagnant, dirty water can retard performance and be a source of disease. Also, water high in sulfates, iron, heavy metals or nitrates can be detrimental to performance. Providing adequate, clean water is a must for optimal performance. Water intake in winter is especially critical for maintaining forage intake and performance of cattle fed dry hay. Cattle generally drink about half a gallon of water per pound of dry matter intake, but this varies considerably with temperature, stage of production and feedstuff moisture level. As an example a mature cow with a daily dry matter intake of 28 pounds would be expected to consume approximately 14 gallons of water. Water requirements, as a proportion of dry matter intake, increase at a greater rate as the temperature rises above thermoneutral temperatures (Table 8-2).

Energy (Carbohydrates and Fat)

Energy is most often the first limiting nutrient for beef cattle. This means energy often is consumed at levels below the animal's requirement leading to reduced production. A positive relationship exists between energy intake and level of production (growth, milk). Energy is needed for movement when grazing, milk production, normal bodily functions such as breathing, growth, fetal development, digestion, and voiding bodily wastes. Dietary energy is commonly expressed as TDN (total digestible nutrients), ME (metabolizable energy), or NE (net energy). Both carbohydrates and fats are sources of dietary energy. Protein consumed in excess of the animal's needs or mobilized from body tissue can also be utilized as an energy source. With proper amounts of protein and minerals, the ruminant animal can obtain energy from forage and roughage products that provide little, if any, energy to non-ruminants.

Table 8-1. Water intake and feed intake of growing steers.

Water Intake	Optimal	20% Decrease	40% Decrease
Feed intake, lb.	13.6	13.0	10.6
% change	-----	-4.5	-22.0

Source: Adapted from Utley et al., 1980 Journal of Animal Sciences.

Table 8-2. Total daily water intake (gallons) as affected by temperature and feed intake.

Temperature	40°F	50°F	60°F	70°F	80°F	90°F
Gallons of water/lb. dry matter	0.37	0.40	0.46	0.54	0.62	0.88
500-lb. calf (12 lb. DM)	4.4	4.8	5.5	6.5	7.4	10.6
750-lb. pregnant heifer (16.6 lb. DM)	6.1	6.6	7.6	9.0	10.3	14.6
1,100-lb. dry pregnant cow (20 lb. DM)	7.4	8.0	9.2	10.8	12.4	17.6
1,100-lb. lactating cow (22 lb. DM)	8.1	8.8	10.1	11.9	13.6	19.4

Source: Adapted from Winchester and Morris, 1956. Water intake rates of cattle. Journal of Animal Science 15:722.

TDN is the measure of energy commonly used when discussing the energy needs of mature cows. TDN values are readily available for most feedstuffs in publications and can be calculated from routine laboratory proximate analyses. Net Energy for maintenance (NEm) is utilized more often today in publications. The Net Energy System partitions nutrients into their basic biological functions within the animal. For instance, maintenance, growth and lactation are often used to discuss nutrient needs for these different functions. However, due to the beef cattle managers' familiarity with TDN and the fact that the NE values are typically derived from calculations using TDN, TDN continues to be used frequently when discussing the energy balance of beef cows. Net energy for gain (NEg) is the energy term used for growing and finishing of cattle while Net Energy for Lactation (NEl) is used by the dairy industry. The net energy system is a more precise measurement as it is divided into maintenance, lactation and gain. However, nutrient balance is the only concept that beef producers need to fully understand. Excess supply will lead to increase in body condition while an energy deficit will mobilize body stores and lead to tissue loss.

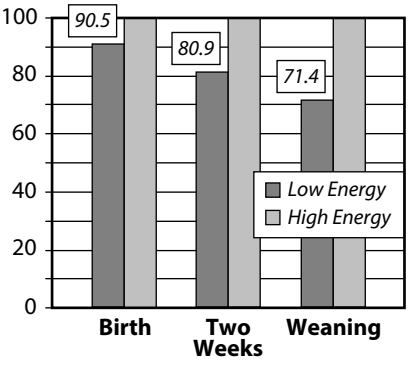
Cattle differ significantly in the efficiency with which they use nutrients. Factors influencing utilization efficiency include breed, genetic ability to milk, actual level of milk production, body composition, and others. In recent literature, several researchers have investigated the use of residual feed intake (RFI) as a tool to select for growth efficiency. Residual feed intake is simply the difference of actual intake of an individual to support a level of production in comparison to the expected intake based on modeled intake data. Residual feed intake has been shown to be moderately heritable. Research has shown that metabolizable energy used for maintenance varies between cows within a breed by as much as 35%. This provides some evidence that efficiency can be improved through genetic selection. However, at this point in time, the research is not clear as to whether this tool has merit for the cow herd. As additional research is conducted, selection criteria may be developed to aid in improving efficiency through breeding programs. There are practical aspects to consider with regards to production efficiency that can be considered today for balancing the production level and feed resources to improve the beef system efficiency.

Body composition and genetics that alter muscle-to-fat ratios can influence nutrient efficiency. Internal organs can account for up to 50% of the maintenance requirement. Highly metabolically active cows, such as cows with high levels dry matter intake, will in turn have high maintenance energy requirements as the liver is often larger to support the higher metabolic activity. Additionally, cows with greater internal fat content have decreased maintenance energy requirements, while those with greater protein mass have increased needs. Lean, heavily muscled animals are expected to have greater maintenance needs. Increased body protein is associated with increased internal organ weight, greater protein turnover and increased metabolic rate. The energy-efficient cow will spend fewer nutrients on body protein maintenance and have more for other production areas such as milk or partition more to body tissue reserves. This is not to say that muscling should not be selected for in the genetic program, rather a realization that a greater plane of nutrition will be needed in the future as muscling increases.

The Costs of Energy Deficiency

Energy deficiencies affect cow fertility, calf health, and survival as well as growth rate of calves. Reproduction is influenced by energy balance and body reserves of the cow. Energy deficiencies occurring prior to calving increase the days of the postpartum interval, the period from calving to first estrus. Increasing this time means later-breeding cows, younger calves at weaning next year and subsequently lighter weaning weights. Weaning weight of calves can be expected to decrease 35 to 45 pounds for each heat cycle missed. Any factor resulting in increased postpartum interval has significant economic implications to beef producers. Energy deficiencies that occur after calving results in reduced fertility and conception rates during a controlled breeding season. Depending on when an energy deficiency occurs, producers will have either fewer calves to wean or lighter calves to sell the next year.

Figure 8-1. Energy deficiency and calf survival.



The effect of an energy deficiency in the pre-calving cow on calf survivability is shown in Figure 8-1. All cows used in this experiment were bred through artificial insemination (AI) allowing for a known expected calving date. During the last trimester of gestation, all cows were placed on energy-deficient rations in order to lose body condition. As each cow reached 30 days from the expected calving date, cows were either left on the energy-deficient ration or were switched to a diet that allowed them to regain all of the body weight previously lost. After calving, the energy-deficient cows were placed on the high-energy ration. Ten percent of calves born to the energy-deficient cows died at or within 48 hours of birth. An additional 10% died from this period to 14 days of age, with an additional 9% death loss occurring from 14 days of age to weaning. A total death loss of 29% of the calf crop resulted due to late-gestation energy deficiencies in the brood cow. Though this may be an extreme situation, it illustrates the importance of meeting the nutritional needs of the beef cow during gestation and early lactation. More importantly, beef cattle managers need to understand that nutrient needs are not static and change given the phase of production. Table 8-3 illustrates the nutrient requirements for beef cows and differences across the various phases of production. Feeding the same diet during the start of late gestation through early lactation is common. This practice leads to significant weight loss for spring calving beef cows. Body condition loss is due to the inadequate levels of nutri-

Table 8-3. Recommended nutrient requirements for 1,400 lb. beef cow with 23 lb. peak milk production and giving birth to a calf weighing 85 pounds.

	Early Lactation			Mid-Lactation		Late Lactation		Dry, Mid-Gestation			Late Gestation	
	Months Since Calving											
	1	2	3	4	5	6	7	8	9	10	11	12
	NEm Required, mcal/d											
Maintenance	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Pregnancy	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.7	1.3	2.3	3.8	5.8
Lactation	7.0	8.4	7.6	6.1	4.5	3.3	2.3	1.6	1.1	0.7	0.5	0.3
Total	18.3	19.7	18.9	17.4	15.9	14.8	14.0	13.6	13.7	14.3	15.6	17.4
	Metabolizable Protein Required, g/d											
Maintenance	466	466	466	466	466	466	466	466	466	466	466	466
Pregnancy	0	0	1	2	3	7	14	26	48	85	147	242
Lactation	512	614	552	442	331	239	167	114	77	52	34	22
Total	978	1080	1019	910	800	712	647	606	591	603	647	730
	Calcium Required, g/d											
Maintenance	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
Pregnancy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7	11.7	11.7
Lactation	24.1	28.9	26.0	20.8	15.6	11.2	7.9	5.4	3.6	2.4	1.6	1.0
Total	42.9	47.7	44.8	39.6	34.4	30.0	26.7	24.2	22.4	32.9	32.1	31.5
	Phosphorus Required, g/d											
Maintenance	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Pregnancy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	4.8	4.8
Lactation	13.7	16.4	14.8	11.8	8.8	6.4	4.5	3.1	2.1	1.4	0.9	0.6
Total	28.0	30.7	29.1	26.1	23.1	20.7	18.8	17.4	16.4	20.5	20.0	19.7
	Weight, lb.											
Shrunk BW	1344	1344	1344	1344	1344	1344	1344	1344	1344	1344	1344	1344
Gravid Uterus	0	0	2	3	6	10	16	26	41	62	94	137
Total	1344	1344	1346	1347	1350	1354	1360	1370	1385	1406	1438	1481

ent supplied from the forage to meet the increased needs to support milk production.

The calf death losses occur due to prolonged labor and dystocia-related problems combined with reduced transfer of protective immunoglobulins to the newborn calf. First calf heifers and thin cows produce less colostrum and fewer antibodies are contained in the colostrum. Calves born to thin cows will have a lower concentration of blood immunoglobins as a result of consuming less concentrated colostrum increasing their risk to disease. Calves born to thin cows will have less brown fat which is important for body temperature maintenance, less strength to stand and likely consume less colostrum. For calves that do survive, sickness rate or "morbidity" will be increased and growth or weaning weight will be decreased (Table 8-4).

Underfeeding energy will have a marked negative effect on cow herd performance and cows should be fed to maintain an ideal body condition score. Increased knowledge on fetal programming from recent research also demonstrates the importance of meeting the nutrient needs of cows. Nutrient restriction during gestation can result in negative impacts on subsequent health, growth and other factors of the unborn fetus later in life.

Table 8-4. Passive transfer of immunity in the calf, health, and growth.

IgG Level	Inadequate	Adequate
Calves, number	60	183
% sick	25	4.9
Weaning weight, lb.	471	495

Source: American J. Vet. Res. 56:1149.

Protein

Amino acids are the "building blocks" for muscle and other body proteins. These amino acids contain nitrogen along with other elements such as carbon, hydrogen, oxygen and sulfur. Another unique feature of ruminants is the ability to utilize non-protein nitrogen (NPN) such as urea, biuret and diammonium phosphate as a source of nitrogen which can be incorporated into amino acids by the rumen microbes. Urea is toxic to mammalian cells and is excreted from the body, yet the rumen microbes can break down urea and build microbial protein. The microorganisms break down much of the dietary protein and synthesize it into microbial protein. As microbes are washed out of the rumen, they are digested to yield amino acids which are absorbed by the animal to make muscle, milk and other proteins.

Protein is generally expressed as crude protein on feed tags and in feed analyses. Crude protein in feed is actually the measured concentration of nitrogen (N) x 6.25 to make it "equivalent" to true protein. However, not all nitrogen can be converted to true protein. Currently, protein requirements of the animal are expressed as metabolizable protein rather than crude protein. The use of metabolizable protein recognizes that diets must meet the nitrogen needs of the rumen microbes for optimal fermentation as well as the amino acid needs of the animal. The metabolizable protein system accounts for rumen degradation of feed/forage protein by separating dietary protein into degradable (DIP—degradable intake protein) and undegradable (UIP—undegradable intake protein). Protein in the feed/forages that is altered by the rumen microbes is referred to as DIP, while the fraction of protein escaping rumen modification is referred to as the UIP portion.

Cattle with developed rumens therefore have two protein requirements. First, the nitrogen needs of the rumen bacteria must be met, and then the amino acid requirement of the animal is balanced for optimal performance. The microbial nitrogen requirement is derived from the degradable intake protein (DIP) contained in the feed consumed and urea that is recycled to the rumen. Degradable protein may be either true protein or nitrogen from sources such as NPN. The amount of DIP required by the microbes is estimated by modeling the potential rumen fermentation that may take place based on a general knowledge of the feeds consumed. The amount of microbial protein yield is positively correlated with TDN

intake. The more fermentable the feed, the greater the microbial growth and replication yielding more microbial protein.

Metabolizable Protein Example

30 lb hay consumed x (7% ÷ 100) x (60% DIP ÷ 100) = 1.26 lb DIP consumed

DIP needed 30 lb hay consumed x 50% TDN = 15 lb TDN intake

15 lb TDN intake x 10% DIP/TDN = 1.5 lb DIP needed

Supplemental DIP needed = needs – intake = 1.5 lb DIP needed – 1.26 lb DIP consumed = 0.24 lb supplement

Corn gluten feed contains 22% protein which is 65% DIP = 22% x 65%/100 = 14.3% DIP

0.24 lb DIP supplemented needed ÷ 14.3% DIP from corn gluten feed = 1.67 lb DM corn gluten feed

1.67 lb DM corn gluten feed ÷ (90% DM/100) = 1.86 lb as-fed corn gluten feed supplement

Using metabolizable protein allows one to estimate the DIP needs of the animal based on the TDN intake. Degradable intake proteins needs are estimated by using a relationship of 10%-13% of the daily TDN intake. For example if a cow is consuming 30 lb. of forage with a TDN of 50%, the TDN intake is calculated to be 15 lb. TDN intake and the DIP requirement would be approximately 1.5-2.0 lb. If the cow was consuming a low quality hay that contained 7% crude protein and it is 60% degradable, the DIP consumed would be 1.26 lb. DIP (see Metabolizable Protein example). To balance the cows DIP needs an additional 0.24-0.74 lb. of DIP would need to be provided from a supplement. Providing more digestible feedstuffs results in greater microbial protein production as long as adequate DIP is available to support the needs of the microbes.

True proteins that escape rumen breakdown but are available for digestion and absorption in the small intestine are known as undegradable intake proteins (UIP). A small fraction of dietary UIP is completely unavailable and passes directly out of the animal. The total amino acids available for absorption in the small intestine are composed of UIP from feed consumed and microbial protein from the rumen.

For optimal gain, cattle must be fed a balance of UIP and DIP as shown in Table 8-5. Corn silage is a low protein feed, and the vast majority of its protein would be DIP. Research was conducted in which cattle were given either no supplemental protein, a supplement consisting of a DIP source only (urea) or a source containing both DIP and UIP (soybean meal). Both supplements provided the same amount of supplemental crude protein. Cattle fed the soybean meal gained significantly more than both the unsupplemented cattle or those supplemented with urea.

Table 8-5. DIP and UIP must be met for optimal gain of cattle.

	Corn Silage (CS)	CS + Urea (DIP)	CS + SBM (DIP and UIP)
Study A			
Initial wt., lb.	686	686	688
CS intake, lb.	33.4	35.5	35.6
ADG, lb.	1.3	1.7	2.0
Study B			
Initial Wt, lb	413	412	415
DM Intake, lb	11.4	13.6	14.2
ADG, lb/d	0.95	1.94	2.14
Feed/Gain	12.6	7.0	6.6

Source: Study A: Boling et al., 1972 J Nutrition; Study B: Horton et al., 1992 Can J Anim Sci 72:3.

Mature, low-quality hay and crop residues are often deficient in DIP. This limits microbial growth and negatively impacts fiber degradation. Inadequate DIP results in reduced feed/forage intake due to the slower rates of digestion and subsequent reduced passage rates resulting in longer retention in the rumen. Supplementing energy in the form of grain such as corn that is low in DIP and high in starch which is rapidly fermented by the microbes will not improve performance of cattle. To ensure adequate rumen ammonia for microbes, the diet should contain at least 7% available crude protein. Thus, corn gluten feed, soybean meal, dried distiller grains or some other protein supplement is needed to meet the DIP of the rumen microflora when the forage protein level is below 7% crude protein. This is not to say that the protein level needed for beef cows is only 7%, this is what is needed for the rumen microbes. Dietary crude protein requirement may be as high as 13% for a lactating beef cow. The metabolizable protein needs for mature cows can be found in Table 8-3.

Minerals

Minerals are an essential part of the beef cow's nutritional needs. At least 17 minerals are known to be required for beef cattle. The normal forage-based diet in Kentucky provides most of them. However, a good mineral supplement should be available to cows at all times to balance the supply from the forage and the need of the animal. Examples of complete mineral supplements that could be offered to beef cows on fescue are shown in Table 8-6. These UK IRM mineral specifications provide manufacturers a set of specifications for a fescue-based mineral product for beef producers.

Calcium (Ca)

In general, calcium deficiency is rarely an issue for beef cattle grazing cool-season pasture mixtures or consuming a forage-based diet. Calcium is the most abundant mineral in the body and plays key roles in nerve signal transduction, muscle contraction, bone development and others. Most forages contain adequate levels of calcium to meet the needs of cattle during periods of low production or low rates of gain. Supplementation may be necessary during lactation and when high rates of gain are desired. It is recommended to maintain a calcium to phosphorus ratio in the diet of at least 1:1 with 2:1 often being the recommended target. Although calcium is important in the diet, avoid excessive supplementation and do not exceed a Ca:P

ratio of 7:1. Excessive dietary calcium will decrease the absorption of phosphorus, magnesium, and certain trace minerals. Low calcium is most often found in cattle fed high grain diets and/or diets containing significant amounts of grain-derived coproducts. High grain diets often result in a Ca:P imbalance contributing to urinary calculi. Growing cattle diets should contain a minimum of 0.6% calcium and may need to be greater to ensure an adequate Ca:P ratio when dried distillers grains and corn gluten feed comprise a significant part of the feed consumed.

Table 8-6. UK IRM beef mineral guidelines.[1]

Level	Basic[2]	IRM Basic Adj 4 Ounce	High Magnesium[3]
Salt, %	22-25	17-19	15
Mg, % (from MgO)	2	1.5	14
Ca, %	11-12	8-9	12
P, %	4	3	6
K, %	0.5	0.4	0.1
S, % (maximum)	1	0.8	0.8
Cu, ppm	1,600	1,200	2,000
Zn, ppm	3,200	2,400	4,000
Se, ppm	35	26	26
I, ppm	65	50	50
Co, ppm	15	12	12
Mn, ppm	3,750	2,800	3,000
Fe (iron)	None added	None added	None added
Vit. A, IU/lb.	150,000	115,000	150,000
Vit. E, U/lb.	150	110	150

[1] UK IRM formulation specifications can be found at UK Regulatory Services (http://www.rs.uky.edu/regulatory/feed/)
[2] Distiller's dried grains (40 lb./ton), wet molasses (20 lb./ton), and mineral oil (20 lb./ton).
[3] Distiller's dried grains (100 lb./ton), wet molasses (20 lb./ton), and mineral oil (20 lb./ton).

Phosphorus (P)

Phosphorus is a mineral that can vary dramatically with respect to being adequate in the forage base to deficient. The need for phosphorus increases during lactation (milk production) and periods of skeletal and muscle tissue growth. Phosphorus is stored in the bones acting as a reserve. Phosphorus is integral to several functions in the body including energy metabolism, reproduction, bone development, and many others. Phosphorus deficiencies can cause poor growth, reduced appetite, poor digestibility of feedstuff, and poor reproduction. Over supplementation of dietary phosphorus is undesirable since it may reduce magnesium absorption, increase urinary calculi, is detrimental to surface water quality and increases feed costs.

In general, most cool-season grasses grown on soils that are properly fertilized provide sufficient phosphorus to beef cows except during early lactation. The standard 2:1 minerals which are typically 12% calcium and 6% phosphorus are not always warranted, however. Often, a mineral with a Ca:P ratio of 3- or 4:1 containing 12% calcium with 3-4% phosphorus is sufficient to balance forages grown on farms with good soil fertility.

When high levels of corn-based coproducts such as dried distillers grains and corn gluten feed are used as supplements, the phosphorus intake is increased as these feedstuffs contain high concentrations of phosphorus. As a general rule of thumb, three pounds of corn gluten feed or dried distillers grains provides approximately the same phosphorus intake as 4 ounces of a 6% mineral product. It is necessary to provide additional calcium to maintain an adequate calcium to phosphorus ratio to prevent urinary calculi in corn-based diets and when higher levels of corn-based coproducts are used as supplements at moderate to high rates. For instance a corn silage-based diet with corn gluten feed as the protein source would have approximately 0.2% calcium and 0.4% phosphorus when 30 pounds of corn silage and 5 pounds corn gluten were fed as-is. This ratio is inverted and could lead to water belly after a period of time on feed. Adding dietary calcium, such as feed-grade limestone, to increase the calcium content to 0.6-0.8% is necessary in this example.

Magnesium (Mg)

Cattle require supplemental magnesium under certain conditions. Grass tetany (hypomagnesemia or low blood magnesium) can be a severe problem for lactating brood cows grazing cool-season pasture, such as fescue, during early spring or when lactating cows are grazing or consuming cereal grain forages such as wheat, rye or triticale (known as winter tetany). Excessive nitrogen and potassium fertilization along with low soil phosphorus can exacerbate the low magnesium concentration in plants.

Prevent grass tetany by adequately supplementing magnesium. Magnesium intake should be about 20 to 25 grams from the total diet. Spring calving cows should be started on a high magnesium free-choice mineral at least 4 weeks prior to the first calf being born. Provide supplemental magnesium during late winter through the time when soil temperatures are stable at 60 degrees Fahrenheit in the spring or approximately mid-May. To achieve these supplemental levels using a free-choice mineral supplement, the supplement should contain a minimum of 10% and upwards of 15% Mg with a targeted intake of four to five ounces per head per day. This level of consumption will supply adequate Mg to greatly reduce the risk of grass tetany. Alternatively, magnesium oxide can be mixed at a rate of 75 lb. of feed-grade magnesium oxide per ton of grain (ie. ground corn) and fed at a rate of 2 lb./cow daily. It is critical to monitor intake of high magnesium mineral products. Mineral supplements must be palatable and consumed at the target intake to ensure sufficient magnesium consumption to lower the incidence of grass tetany. A cheap mineral that is not consumed is not cheap when low intakes result in the death of an animal.

Potassium (K)

Forages are excellent sources of potassium; thus, a deficiency in grazing beef cattle is unlikely under most conditions with supplementation rarely needed for cattle consuming Kentucky forages. Excessive

intake of potassium should be avoided to prevent reduction of magnesium absorption. Cereal grains are low in potassium, and cattle consuming high-grain diets must be supplemented. Newly weaned or stressed calves will also benefit from short-term, 5-10 days, supplementation of potassium with an improved health response. Stress increases excretion of potassium by the kidney and is why newly received and/or calves being weaned can benefit from potassium supplementation for approximately a week following arrival or weaning. Most forages from Kentucky provide excess potassium and additional supplementation is not warranted.

Sulfur (S)

Sulfur is a component of certain amino acids, as well as some B-vitamins. Rumen microbes therefore need an adequate rumen sulfur level. High grain rations with a significant amount of nonprotein nitrogen, such as urea or biuret, are likely to require supplementation. An exception to this would be if corn-based coproducts (i.e. distillers grains, corn gluten feed) which often contain high levels of sulfur are a staple of the diet as these feedstuffs generally are high in sulfur concentration. Although deficiencies could occur, excessive intake is often of greater concern today. High dietary sulfur, above 0.25%, combined with high molybdenum intakes can greatly reduce copper availability leading to copper deficiency. When determining total sulfur intake, water must also be considered as a source. Recent research has illustrated that water containing high sulfate levels reduces gains of growing calves and sulfur springs in Kentucky contribute to high sulfur intakes when cattle drink from them. High dietary sulfur will also interfere with selenium absorption and increase the risk of polioencephalomalacia or PEM.

Cobalt (Co)

Cobalt is essential for the production of vitamin B12 by the rumen microflora. Vitamin B12 is required for cattle as it is involved in two key metabolism processes. Deficiencies in cobalt results in low vitamin B12. Signs include reduced appetite and poor growth. Severe deficiencies include unthriftiness, body condition loss and decrease fat metabolism by the liver leading to fat accumulation in the liver. Recently, the cobalt requirement was increased to 0.15 ppm (dry matter basis) in the total diet for beef cattle. Cobalt sulfate and carbonate are common inorganic sources used in supplements. Some feed companies may also provide cobalt as an organic source, such as cobalt glucoheptonate, in which the mineral is attached to a sugar molecule.

Copper (Cu)

Copper deficiency is widespread for grazing cattle throughout the world and is one of the most common trace mineral deficiencies observed in Kentucky. Copper is necessary for growth, reproduction, and immunity. Forages vary widely in their copper content and availability. Copper deficiency is commonly associated with low pregnancy rate (<70%) in Kentucky. The copper concentration of tall fescue often provides only 60% of the daily requirement for beef cattle. Further, the bioavailability of copper in tall fescue is very low ranging from only 5-15% meaning the actual amount retained by the animal is about a tenth of what is needed. Several other minerals may interfere with copper absorption. Research has shown that molybdenum levels greater than 2 to 3 ppm, iron greater than 250 to 500 ppm, and sulfur greater than 0.25% of dry matter intake reduce the availability of copper. When these minerals are consumed at high levels, it is necessary to increase the dietary copper requirement. Intake of several other minerals must be considered when supplementing copper to the diet. One cannot simply feed extremely high levels of copper as this can lead to antagonisms interfering with the absorption of other trace minerals inducing another deficiency. Breed also affects the copper requirement. Simmental and Charolais cattle require higher levels of copper than Angus as a result of increased excretion and/or decreased absorption.

Zinc (Zn)

Zinc is another trace mineral commonly deficient in the forages. Zinc is essential for normal growth, fertility, and immune function. Very little zinc is stored in the body, so deficiencies occur rapidly when dietary intake becomes inadequate. Excessive levels of iron and/or calcium in the diet reduce zinc absorption. Zinc should be supplemented to beef cattle.

Selenium (Se)

Selenium content in forages is often marginal to deficient. Next to copper, selenium is the next most common trace mineral deficiency observed in cattle in Kentucky. Low levels of vitamin E will increase the selenium requirement, but this is generally not an issue with grazing cattle. Excessive sulfur from forage or water will increase the selenium requirement. Because of the narrow margin between deficiency and toxicity of this mineral, supplementation cannot legally exceed 3 milligrams per head daily for beef cattle. Mineral supplements should be formulated to deliver this level of selenium to avoid a deficiency. The use of yeast derived selenium products increase the bioavailability of selenium. Recent research suggests that the use of both sodium selenite and seleno-yeast products provide up-regulation of key genes for beef cattle health and fertility.

Manganese (Mn)

Manganese is involved in several enzyme systems and is necessary for adequate reproduction in both the male and female. Forage manganese content can be quite variable depending on the soil type and other factors. Forage content is not generally meaningful as adult cattle absorb only 3 to 4% of the manganese in forages. Thus, it should be included in the mineral mix. A rare disorder known as congenital chondrodystrophy of unknown origin is believed to be linked to a manganese deficiency associated when only fermented feedstuffs are fed without any dry feed/forages. A low level of dry feed along with manganese supplementation appears to prevent this disorder.

Iron (Fe)

Iron is an essential component of several proteins involved in oxygen transport in the body. Most forages contain more than adequate iron to meet cattle requirements; thus, true iron deficiency is rare in cattle. Excessive intake of iron is more likely a problem for grazing cattle.

Water sources also contribute to iron intake of cattle. In addition, the sources of calcium and phosphorus used in mineral supplements contain significant amounts of iron contributing to the amount consumed. Several commercial mineral supplements contain ferric oxide

as a coloring agent which is not needed and essentially of no nutritional value due to its low bioavailability. The iron from ferric oxide is unavailable but may interfere with absorption of copper. Generally, there is little reason to add iron to mineral supplements for grazing cattle.

Molybdenum (Mo)

Molybdenum is a component of some enzymes, but a true dietary requirement for grazing cattle has not been established. Excessive molybdenum intake is a concern because of its antagonistic effect on copper. A molybdenum content in a ration greater than 2 or 3 ppm can reduce copper availability increasing the need for copper supplementation.

Salt (NaCl)

Salt (sodium and chlorine) is deficient in the forage diet and generally makes up a large part of the mineral supplement. Animals normally consume the mineral mix because of their "craving" for salt. This may be due to the fact that forages often only provide about 60% of the sodium requirement for grazing cattle. However, straight salt should not be used due to the fact that several other minerals are needed by the animal. Providing access to straight salt will reduce the intake of a complete mineral product limiting the intake of it and the other needed minerals.

Chelated Minerals

Chelated (organic) minerals sources are also available in many commercial mixes. Chelation is the process in which a metal/mineral ion is chemically bound to an amino acid or sugar. Proteinated sources are a special form of chelated minerals. Chelation can alter the availability of minerals, in most cases enhancing the uptake of the mineral. If the bioavailability of a mineral is increased, lower dietary concentrations can be used. This form of mineral is frequently recommended in the presence of antagonists when deficiencies are observed using inorganic sources. The chelated or "organic" forms of minerals appear to regulate different genes, are better at immune system stimulation, and enhance reproduction/fertility when antagonists limit mineral uptake. Compare the costs of chelated mineral sources to inorganic mineral sources; it might be more cost effective to simply increase the amount of inorganic minerals supplemented. To determine if a mineral supplement contains organic sources of minerals, look at the ingredient section of the feed tag. Examples of these sources will include wording similar to copper lysine, zinc proteinate, cobalt glucoheptonate, manganese amino acid complex and selenium yeast. The amount that each source contributes to the level on the tag cannot be determined by the tag alone. Ask the feed dealer the amount or percent derived from inorganic and organic sources.

Hydroxy Trace Mineral Analogues

Another relatively new form of trace mineral supplementation are the hydroxy analogues. They appear to have a higher bioavailability than oxide and sulfate forms and generally cost less than chelated forms. Basic copper chloride, zinc hyrdoxychloride and manganese hydroxychloride are the sources found on feed tags representing this category of minerals. These are inorganic forms, but due to their chemical structure, they escape rumen modification increasing their availability. These sources can be considered when sulfate forms are less than ideal due to high water sulfates or as a lower cost alternative to chelated forms. More manufacturers are beginning to utilize these sources and you will see them listed on mineral tags under the ingredient section.

Today there are quality commercial mineral supplements available from most feed manufacturers. The mineral supplement needed varies depending on the time of year, the cow's stage of production, other ingredients in the diet, and, perhaps, breed and the geographic area of the state (some regions might be marginal or deficient in certain microminerals). As a general guide, the UK IRM mineral specifications were developed to provide producers a mineral product that could be used free-choice for fescue-based beef herds. These specifications can be found in Table 8-6. These specifications can be used to obtain bulk purchase bids. These specifications cannot be used to compare mineral tags as differences in target intakes may exist. Corrections based on expected intakes to determine actual mineral intake is needed to compare mineral products. Differences exist between mineral products labeled for free-choice consumption versus mineral products designed to be mixing minerals or those to be mixed with other feedstuffs before being fed. Read the feed tag and use products in accordance to the feeding directions listed on the tag. Note, as new research becomes available, the UK IRM specifications are altered and one should contact their county extension office for the most current guidelines.

Vitamins

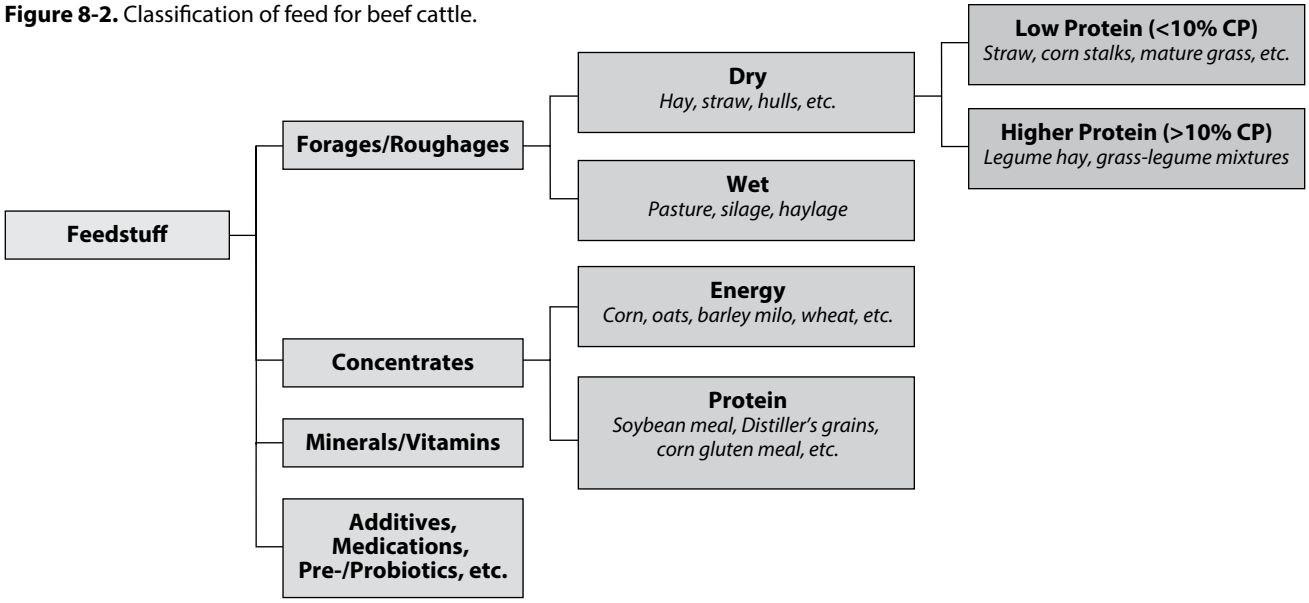
Vitamins belong to two groups: fat-soluble (A, D, E, and K) and water-soluble (B vitamins and vitamin C). Bacteria in the rumen and intestines make the necessary water-soluble vitamins and vitamin K. Vitamin D is synthesized in the skin when animals are exposed to sunlight or ultraviolet light waves. Vitamin E is found in most feeds. This leaves vitamin A as the only mineral that may be deficient under normal situations.

Vitamin A can be synthesized in the body from carotene, which is found in plants. Vitamin A deficiency is rare when good-quality forages are fed to beef cattle. Vitamin A deficiencies can occur when the diet consists of weathered or low-quality hay and concentrates low in carotene content, such as old corn, white corn, small grains, or grain sorghums. Cattle that are fed or that graze forages high in nitrates can have a vitamin A deficiency due to poor use of carotene.

You can add supplemental vitamin A to the diet or mineral supplement as a dry, stabilized vitamin A premix, or give it as an injection. An injection of 1 million IUs prevents deficiency symptoms for two to four months in cattle. The most common method is to provide a mineral/vitamin supplement with approximately 150,000 to 200,000 IUs of vitamin A per pound of mineral.

During periods of high stress, calves receiving a higher level of vitamin E supplementation have been shown to have a lowered incidence of morbidity and mortality. When cattle are off feed or have low intakes, the rumen microbes may not produce sufficient water soluble vitamins and vitamin B supplementation may stimulate intake and reduce morbidity. Sustained vitamin B supplementation is not required however.

Figure 8-2. Classification of feed for beef cattle.



Classification of Feeds

Feedstuffs are generally divided into two broad categories: roughages/forages and concentrates. Roughages/forages are usually high in fiber and low to moderate in energy. Concentrates, on the other hand, are low in fiber and high in energy. Categories are sometimes further divided into energy and protein feeds. These feedstuffs may require mineral and vitamin supplementation or feed additives. Figure 8-2 shows various feeds classified according to their use.

Various feedstuffs are available for use in beef cattle diets. Brief descriptions of several ingredients used to supplement forage-based diets follows. Table 8-7 shows nutrient concentration and feed density of several types of feeds.

Corn is the most widely fed grain. It is used as an energy source and is low in crude protein, fair in phosphorus, and low in calcium. Corn is fed in different forms—shelled corn, whole ear corn, and high-moisture corn (20% to 34% moisture)—and may be processed to different degrees. Corn-and-cob meal consists of whole ears of corn (cob and grain), ground to varying degrees of fineness. The mixture is usually about one-fourth cobs and three-fourths corn grain. It is a good feed for growing calves because of its increased fiber content. The whole corn plant can also be harvested and ensiled. Corn silage consists of approximately half corn and forage making it a moderately high energy forage for beef cattle. Standing corn can also be grazed by cattle in the field.

Table 8-7. Nutrient composition of common feedstuffs fed to beef cattle.

Feedstuff	DM, %	Protein, %	TDN, %	NEM, Mcal/lb	NEg, Mcal/lb	Ca, %	P, %
Alfalfa hay	87	19.8	55.2	0.52	0.27	1.47	0.26
Bermudagrass hay	93	11.1	56.3	0.54	0.28	0.49	0.20
Corn stalks	86	6.1	52.7	0.48	0.23	0.55	0.11
Fescue hay	89	9.2	58.3	0.57	0.31	0.48	0.22
Wheat Straw	92	5.1	50.0	0.44	0.19	0.33	0.11
Corn silage	33	8.2	67.7	0.71	0.44	0.24	0.23
Corn, whole shelled	87	8.8	87.6	0.99	0.68	0.03	0.29
Oat grain	90	12.6	83.0	0.92	0.62	0.10	0.38
Sorghum / Milo grain	89	11.6	86.0	0.96	0.66	0.06	0.34
Wheat grain	89	13.8	86.8	0.98	0.67	0.08	0.36
Beet pulp	92	9.1	66.6	0.69	0.42	0.96	0.08
Brewers grains, wet	26	28.5	73.9	0.80	0.51	0.35	0.68
Citrus pulp	88	6.9	70.0	0.74	0.47	1.84	0.11
Corn Gluten Feed	90	22.6	74.0	0.88	0.59	0.10	1.01
Cottonseed hulls	91	6.7	36.6	0.20	--	0.22	0.16
Dried Distillers Grains	90	30.8	82.0	1.00	0.69	0.05	0.86
Peanut hulls	93	9.5	42.8	0.32	0.08	0.29	0.10
Rice bran	92	14.7	83.4	0.93	0.63	2.04	1.61
Rice hulls	92	5.4	31.5	0.13	--	0.18	0.31
Soybean meal, 49%	89	52.9	79.5	0.88	0.58	0.42	0.75
Soyhulls	90	12.4	62.6	0.64	0.37	0.60	0.15
Wheat middlings	89	18.6	72.9	0.79	0.50	0.12	1.08

Adapted from the National Animal Nutrition Program https://animalnutrition.org/beef with permission.

Wheat is about 105% the feeding value of corn when it makes up no more than 50% of the beef ration. It is a good feed but can pack in the rumen, especially when it is finely ground. Additionally, due to the rapid rate of starch digestion in the rumen which increases the risk to acidosis, it is often recommended to be limited to not more than 30% of the total diet.

Sorghum grain (milo) is about 85 to 90% the value of corn for beef cattle. It is lower in energy than corn and more variable in its protein content. Sorghum grain must be processed for maximum digestibility. Milo is generally grown as a crop when it is too late to plant corn or in areas that are susceptible

to drought. High tannin varieties are common and lower the DIP requiring additional protein supplementation.

Oats are about 85% the feeding value of corn because of their high fiber level. Oats are very palatable and excellent for starting young calves on feed. You can use oats in receiving diets, weaning rations and creep mixtures with levels commonly being 25-50% of the mix.

Rye is the least palatable of all the grains and should not make up more than one-third of the ration. It tends to cause digestive disturbances if ground too fine. Rye also can be contaminated with ergot, which can cause vasoconstriction of blood vessels leading to similar complications seen from the alkaloids produced by the endopyhte found in tall fescue.

Many commercial protein supplements are available, and most contain some of the following ingredients (which also may be fed as the sole protein supplement).

Soybean meal (SBM) is the gold standard natural protein supplement for cattle as it has the most ideal amino acid profile for growing calves. It is the most widely used of all the oilseed meals and is the standard to which other protein supplements are compared. The amino acid composition of soybean meal makes it an excellent supplement with corn, which is deficient in lysine. This amino acid composition is beneficial to young, growing calves. However, due to its cost, it is often not the preferred supplemental source for beef cows.

Whole cottonseed and cottonseed meal is not as readily available in Kentucky as SBM. These protein sources are lower in protein content compared to soybean meal, but can still be fed if available. It is a satisfactory protein supplement for beef cattle, however, whole cottonseeds should be avoided in rations offered to bulls close to breeding as it can lead to temporary infertility. Cottonseed hulls are often confused with whole cottonseeds as they both appear fuzzy. Cottonseed hulls are relatively low in energy being similar to low quality fescue hay with the protein content often not much higher than 5%. Cottonseed hulls are used as a roughage source in grain-based diets to lower the risk of ruminal acidosis and stimulate intakes of newly weaned or received feeder calves.

Urea and biuret are not proteins as they are not comprised of amino acids. These nitrogen supplements can be converted to true protein by rumen microorganisms. The diet should contain readily fermentable energy such as starch, molasses/sugar or rapidly fermentable fiber such as those found in soyhulls, beet pulp, corn gluten feed and similar feedstuffs to optimize the utilization of NPN. Generally, NPN should not make up more than 1% of the total diet or provide more than a third of the total dietary protein.

Liquid supplements are popular with some producers because they can be self-fed from "lick tanks." This makes supplements from "lick tanks" convenient for producers. Today these products are generally molasses/urea-based or a mixture of coproducts, such as condensed distillers solubles, fermentation extracts, or vegetable oil, to provide both an energy and protein supplement. When priced per unit of nutrient such as TDN or crude protein, these products are often more expensive than other feedstuffs but they are an acceptable method of supplementing beef cattle.

Spent grains and liquids from the bourbon and fuel ethanol industries are readily available sources of energy and protein supplementation. There are several marketed products from these industries. Corn is the predominant grain used in the Midwest with varying amounts of other grains, particularly with the bourbon industry. Dried distiller's grains with solubles are the spent grains that have been dried and are a good source of bypass (undegraded intake protein) protein. Spent grains may also be marketed with varying levels of moisture, 50%-75% is typical, and referred to as wet distillers grains and wet cake. The moisture content limits their use to areas near the place of production. To learn more on how to best utilize these feedstuffs consider obtaining factsheet ASC-186: at http://www2.ca.uky.edu/agc/pubs/asc/asc186/asc186.pdf. When feeding stillage or "slop," it is recommended to limit the volume to 1-1.5 gal/100 lb. of live weight as an upper limit to reduce the risk of digestive upsets and other issues.

Corn gluten feed is a by-product obtained when high fructose corn syrup is made. It contains about 20% crude protein. It is also a good source of energy due to the highly digestible fiber content. Another product, which should not be confused with corn gluten feed, is corn gluten meal. The meal contains approximately 65% crude protein and is much higher in cost than the lower protein feedstuff corn gluten feed.

You can feed whole soybeans to beef cattle as a protein supplement. Do not feed them at high levels, however, because of their fat content. Limit them in the diet to replacing the usual protein supplement of cattle (usually 2 to 3 pounds), and do not feed in diets with urea.

Soyhulls, the seed coats of soybeans, are removed during oil extraction. The hulls are very palatable, high in digestible fiber and only slightly higher in crude protein than corn making them an energy source. They also have a low starch level reducing the risk of acidosis. Soyhulls are a good feedstuff for use in creep diets, receiving rations and as supplements to grazing cattle.

Peanut coproducts have recently increased in their use in the region. Peanut skins are high in oil, digestible fiber and tannins. They can be used as an energy source, but should be limited due to the oil content. In addition, higher crude protein levels should be fed to compensate for the protein bound by the tannins in the rumen. Peanut hulls are not very digestible and are used primarily as a filler to lower the risk of founder in self-fed rations. They are not recommended to be used as an energy supplement.

Rice mill products consist of rice bran, rice hulls and rice mill feed which is a mixture of hulls and bran. Rice bran is similar in nutritional quality to soyhulls and can be a good energy supplement. Rice hulls are actually lower in energy than peanut hulls and generally are used as a carrier in vitamin premixes. Rice hulls can lead to rumen compaction and should only be used at low levels to dilute the starch level of self-fed supplement to reduce the risk of acidosis.

Lastly, the Association of American Feed Control Officials permits feed manufactures to utilize collective terms when listing ingredients on a feed tag. With an increased availability of coproducts and feedstuffs combined with variability of access to various feeds, using collective

terms eliminates the need to change feed tags when small changes are made in the formulations. However, this can pose a challenge to producers when trying to purchase a quality supplement for their beef animals. A few collective feed terms utilized are shown in Table 8-8. It is important to note that soyhulls, peanut hulls, cottonseed hulls and rice hulls all fall under the same collective term "roughage products," yet the nutritional value of soyhulls is far superior to the other types of hulls. Producers are encouraged to ask their feed dealers what is contained in the supplements they are purchasing to avoid the purchase of low quality fillers.

Table 8-8. Collective terms (not an all-inclusive list) found on feed tags.

Animal protein products	Animal blood, animal by-product meal, buttermilk, casein, cheese rind, crab meal, fish by-product, fish meal, hydrolyzed hair/leather meal/poultry feathers, meat and bone meal, dried milk, whey
Forage products	Alfalfa hay, corn plant, ground grass
Grain products	Barley, corn, grain sorghum, oats, rice, rye, triticale, wheat
Plant protein products	Algae meal, beans, canola meal, cottonseed meal, linseed meal, peanut meal, peas, rapeseed meal, safflower meal, soybean meal, sunflower meal, yeast
Processed grain byproducts	Brewers dried grains, condensed distillers solubles, corn bran, corn germ meal, corn gluten feed, corn gluten meal, corn distillers dried grains, hominy feed, malt sprouts, oat groats, peanut skins, rice bran, rice polishings, wheat bran, wheat middlings
Roughage products	Almond hulls, apple pomace, bagasse, barley hulls, barley mill feed, beet pulp, citrus pulp, corn cob, cottonseed hulls, flax straw by-product, oat hulls, peanut hulls, rice hulls, rice mill by-product, soybean hulls, straw

Note: Within the roughage product area there are feeds with high nutritive value and some with very poor feed value. It is important that one requests additional information such as the energy content of a blended, complete feed.

Associative Effects of Digestion

The term associative effects of digestion simply means that one feed can impact how another feed is digested when both are fed together. These effects can be neutral, negative or positive and must be considered when deciding on a supplementation program for forage. In general, if we consider the forage intake of a mature cow to be 30 lb. daily and a concentrate was fed as a supplement at a rate of 4 pounds per cow per day, a neutral effect would result in the same forage intake or a total intake of 34 pounds consumed (30 lb. hay + 4 lb. of supplement). A negative associative effect is when the forage intake is reduced as a result of the supplement being consumed. For example 4 lb. of corn is fed and hay intake falls from 30 to 28 pounds, leading to 32 pounds of feed intake. This is common when starch-based feedstuffs are offered to cattle consuming a predominately forage diet that is limited in DIP. Lastly, a positive associative effect is when hay intake is increased as a result of supplemention. In this situation, the total feed intake may be 35 pounds from 4 pounds of supplement plus 31 pounds of hay consumed. This is common when the rumen microbes have been limited in protein and a protein supplement is offered allowing for a faster rate of fermentation and subsequent passage rate of the fiber out of the rumen.

Low starch coproducts such as corn gluten feed, soyhulls and distillers grains are generally safer to feed than corn. This refers to their lower risk of inducing ruminal acidosis. High-corn rations may present the possibility of digestive upset (acidosis) or founder of cattle due to the starch content. Starch is rapidly fermented in the rumen and leads to the production of more volatile fatty acids (VFAs) and stronger VFAs. This can lower rumen pH and negatively impacts the fiber digesting microbes. Soyhulls and corn gluten feed contain little starch and are unlikely to founder cows even if an aggressive cow overconsumes. Some commodities such as condensed distillers soluble, rice bran, and bakery waste contain high fat levels and can upset fiber digestion in the rumen if intake is not limited. The fat in the feedstuff essentially interferes with the microbes' ability to ferment the forage. Wheat middlings are available and represent an excellent feed source. They are more variable and less available in the southeast. Some wheat middlings samples can contain significant amounts of starch from broken grain particles and, if fed at high levels, may present digestive problems.

Low-cost beef producers maximize the use of forage produced on the farm, produce higher quality stored forages for winter feeding and feed cows appropriately to meet the nutritional requirements of cattle as economically as possible. Low cost producers have higher weaning percentages from getting cows bred and weaning a live calf. This is accomplished by meeting the nutritional needs of the cow. These nutritional requirements are influenced by body size, production status, level of milk production, growth rate, and the environment.

Nutrient requirements of the cow vary according to the cow's size, whether the cow is lactating or dry, the level of milk production, and the stage of production. Figure 8-3 divides the beef cow's productive year into periods of differing nutritional requirements according to her stage of production. The following brief discussion of the production groups will help you understand their needs. Not all groups are present in all herds, and your facilities may limit the amount of grouping you can do. If you can only do limited

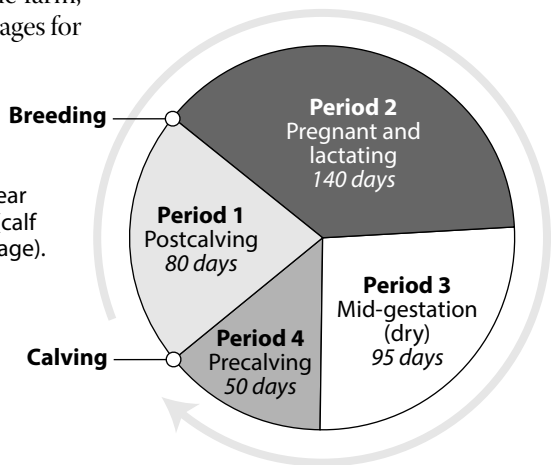


Figure 8-3. Beef cow year by productive periods (calf weaned at 220 days of age).

grouping, separate the animals having the greatest differences in nutrient needs and feed accordingly.

Production Groups of Cattle

Mature, Dry, Mid-Gestational Cow

The mature, dry, pregnant cow in average flesh, body condition score of 5, has the lowest nutrient needs: she can use lower-quality feed than other groups in the herd. Cows in mid-gestation which are dry and in good flesh provide an opportunity to cut feed costs by using such feeds as crop residues, mature standing grass, or mature hay. Recognize that body condition score or the amount of flesh the cow is carrying must be adequate if you use lower-quality feeds. Thin cows that need to regain condition have higher nutrient needs and should be fed a higher plane of nutrition. Lower-quality feeds are not suitable for mature, dry, pregnant cows that are thin and need to replenish body stores.

Mature, Dry, Late-Gestational Cow

The last three months prior to calving are referred to as the last trimester for beef cows. As pregnancy advances, the fetus begins to grow rapidly, especially the last 60 days. These last 60 days are a critical time from a nutrition perspective. In addition to supporting fetal development, mammary tissue nutrient needs are increasing to support the upcoming lactation and for the production of colostrum. During this period, it is important to ensure adequate nutrient supply to avoid weak calves at birth and adequate colostrum production.

Lactating Cow

Nutrient needs increase dramatically after calving when the cow is nursing a calf. Nutrient needs continue to increase until peak lactation is reached which is approximately six to eight weeks after calving. Thus, you should move cows that have calved to a separate pasture and increase the quantity and/or quality of feed. This allows you to better match nutrients provided to nutrient needs and prevents overfeeding of cows that are calving later in the season. For maximum reproductive success, cows should be fed to maintain body condition from calving to breeding. This is rare in most production environments and less than one body condition score loss (ie. 6 to 5) is a realistic goal from calving to breeding if cows are in good body condition, 5-6 body condition score, to ensure the best opportunity of getting cows to breed back.

First-/Second-Calf Heifers

Feed first- calf heifers and second-calf cows (3-year-olds) differently from the mature lactating cow. Unlike the mature cow, their nutrient needs are increased by the need to continue growing. Provide young cows nursing calves the highest-quality feed. A major investment has been made in these young cows and they represent the genetic progress for the herd. Too often herds with poor rebreeding success of these young females is simply due to poor energy and/or protein nutrition. Thin, mature cows can also be managed in this group as they need the additional feed resources to replenish body tissue reserves.

Replacement Heifers

Replacement heifers, both bred and open, comprise another group in most herds. Heifers going into their first winter are at the lowest level of social order in the herd and would certainly be "bossed" by older cows. In addition, their nutrient requirements for growth demand a higher plane of nutrition than that needed by the mature cow. However, this level of nutrition can be met with a level of supplementation of 0.75% to 1% of body weight in many cases. Supplementation levels will depend on the quality of the forages available and producers should test their forages to develop a supplement program to ensure adequate growth rates.

The bred heifer entering her second winter must consume adequate nutrients to support her continued growth and developing fetus. A higher-quality feed than so-called "dry cow hay" is necessary. In addition, avoid getting her too fat. Excess fat can accumulate in the pelvic area causing increased calving difficulties as well as fat deposits in the udder can reduce lifetime productivity. If one can provide high quality forage with enough feeding space available that competition does not occur, bred heifers can be managed with the mature, dry, pregnant cows. Forage test to ensure the hay will meet the nutrient needs of the bred heifers before assuming the quality is sufficient.

Bulls

The bull is often the forgotten animal in winter feeding, but he should not be. If the bull is mature and in adequate condition, the nutritional needs are not difficult to meet. During the winter feed medium-high quality grass hay to maintain body condition or to ensure the bulls reach a target body condition score of 5 to 6 prior to the next breeding season. Over conditioning the mature bull is a waste of feed, money and can negatively impact fertility.

Young bulls are still growing and must be fed accordingly. A high-quality forage and often some concentrate is needed to ensure adequate protein and energy to support growth for these young, developing animals. Growth of lean and skeletal mass is desired. However, they should not gain excessive condition that may impair fertility. If possible, maintain younger bulls in separate lots from mature bulls for feeding and safety reasons. For both mature and growing bulls, ensure that a good free-choice complete mineral supplement is offered as trace minerals are important for sperm development.

Factors That Affect Nutrient Requirements of Cattle

As we continue to select cows for greater milk production, their energy and protein needs are increased. Producers who are constantly selecting sires with high milk EPDs must recognize this and plan for increasing nutrient intake. Nutritional requirements for high milk production can be greater than what the forage base on the farm can support. Eventually, this can result in excessive loss of body condition to support lactation. Dramatic negative energy balance and body condition loss reduces fertility and overall production.

Environmental stresses such as extreme cold or heat can also influence nutrient needs. Cattle require more energy to maintain body temperature in periods of cold stress and to dissipate heat in hot weather. Giving extra feed during periods of extreme cold and providing shade and cool water during heat stress are beneficial practices.

Excessive precipitation can lead to increased energy requirements. Research has shown the force required to lift a foot out of mud increases dramatically as the depth increases above an inch. Cattle constantly forced to walk through mud around feeding areas and forced to lay in wet, muddy areas will expend much more energy than cows in dry conditions. Additionally, the condition of the hair coat will affect its ability to be an insulating barrier. Cold stress is discussed in terms of the lower critical temperature, a point at which more energy is used to maintain core body temperature. A wet winter hair coat has a lower critical temperature (LCT) value near 60 degrees Fahrenheit while the same hair that is dry will have a LCT value of 18 degrees Fahrenheit. Kentucky experiences several days when the temperatures are 35-45 degrees Fahrenheit and raining. These conditions can lead to cold stress or an increase in the energy needed to maintain core body temperature. Feeding adjustments should be made by providing additional dietary energy during periods of cold stress. Maintaining a dry, clean hair coat will optimize its insulating properties and reduce the energetic costs associated with cold stress.

When building a nutrition program for your cow herd, keep three issues in mind: fulfilling the nutrient requirements of the cow, responding to "stress periods" that can cause nutrient deficiencies, and making maximum use of forage supplies while filling gaps with supplemental feed.

Table 8-9. Description of body condition scores (BCS).

Thin Condition	
1.	Emaciated—No detectable fat over backbone, hips, or ribs. All ribs and bone structures easily visible.
2.	Still emaciated but tailhead and ribs are less prominent. Backbone still sharp but some tissue on it.
3.	Ribs still identifiable but not as sharp to the touch. Backbone still highly visible.
Borderline Condition	
4.	Borderline—Individual ribs no longer obvious. Foreribs not noticeable. However, 12th and 13th ribs may still be noticeable, particularly in cattle with big spring of rib. The backbone is still prominent but feels rounded rather than sharp.
Optimal Condition	
5.	Moderate—Good overall appearance. The 12th and 13th ribs are not visible unless the animal has been shrunk. Fat cover over the ribs feels spongy. Area on each side of the tailhead filled but not mounded. The transverse processes (see Figure 8-3) are not noticeable to the eye. Spaces between the processes can only be felt with firm pressure.
6.	High moderate—A high amount of fat present over the ribs and around the tailhead. Noticeable sponginess over the foreribs and on each side of the tailhead. Firm pressure now required to feel the spinous processes.
7.	Good—Cow appears fleshy and carries some fat. Spongy fat cover over the ribs and around the tailhead. Some patchiness evident around the tailhead.
Fat Condition	
8.	Fat—Fleshy and overconditioned. Bone structure disappearing from sight. Animal taking on a smooth, blocky appearance. Large fat deposits over ribs, around tailhead, below vulva. Patchy fat.
9.	Extremely fat—Wasty, patchy, and blocky. Tailhead and hips buried in fat. Bone structure no longer visible. Animal's movement may be impaired.

Evaluating Nutritional Status with Body Condition Scores

Nutritional status can be most easily evaluated by determining the body condition score (BCS) of cows. Body condition scores allow you to evaluate the adequacy of your feeding program and make adjustments to maintain optimal productivity.

Live weight itself does not adequately reflect nutritional status. Two animals with similar weights may be very different in their body condition. For example, a 1,400-pound cow could be a 1,300-pound cow that has gained 100 pounds of body fat or a 1,500-pound cow that has lost 100 pounds of body fat.

Body condition scores are numbers that are used to evaluate body energy reserves of the cow. A scale of 1 to 9, with 1 being extremely thin and 9 being obese, is generally used. Producers should at least be able to recognize the differences in thin (BCS 3), marginal (BCS 4), and optimal (BCS 5, 6, 7) in order to develop a feeding program.

How do you determine body condition? Figure 8-4 shows the areas of the body that are best for scoring body condition, and Table 8-9 provides a description of the condition scores. Examples of condition scores 1 through 9 are shown on the next page. Adequate nutrition from about two months prior to calving and three months after calving is critical to the cow's ability to rebreed and maintain a 365-day calving interval. If the cow gets inadequate nutrition resulting in poor body condition at calving and breeding, she will take longer to come into heat and may require more

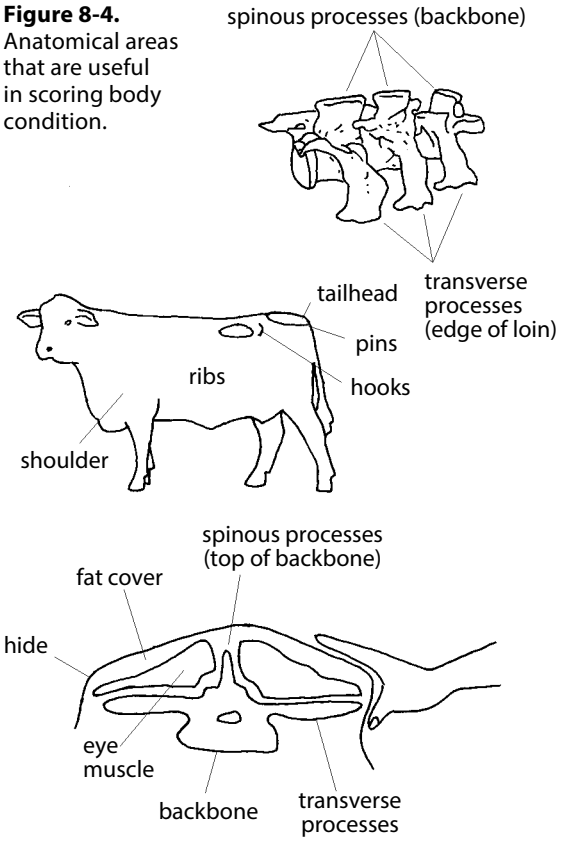


Figure 8-4. Anatomical areas that are useful in scoring body condition.

Figure 8-5. Description of body condition scores (BCS).

Thin Condition

1. Emaciated—Emaciated with no detectable fat over backbone, hips, or ribs. All ribs and bone structures easily visible.
2. Still emaciated but tailhead and ribs are less prominent. Backbone still sharp but some tissue on it.
3. Ribs still identifiable but not as sharp to the touch. Backbone still highly visible.

Borderline Condition

4. Borderline—Individual ribs no longer obvious. Foreribs not noticeable. However, 12th and 13th ribs may still be noticeable, particularly in cattle with big spring of rib. The backbone is still prominent but feels rounded rather than sharp.

Optimal Condition

5. Moderate—Good overall appearance. The 12th and 13th ribs are not visible unless the animal has been shrunk. Fat cover over the ribs feels spongy. Area on each side of the tailhead filled but not mounded. The transverse processes (see Figure 8-3) are not noticeable to the eye. Spaces between the processes can only be felt with firm pressure.
6. High moderate—A high amount of fat present over the ribs and around the tailhead. Noticeable sponginess over the foreribs and on each side of the tailhead. Firm pressure now required to feel the spinous processes.
7. Good—Cow appears fleshy and carries some fat. Spongy fat cover over the ribs and around the tailhead. Some "patchiness" evident around the tailhead.

Fat Condition

8. Fat—Fleshy and overconditioned. Bone structure disappearing from sight. Animal taking on a smooth, blocky appearance. Large fat deposits over ribs, around tailhead, below vulva. Patchy fat.
9. Extremely fat—Wasty, patchy, and blocky. Tailhead and hips buried in fat. Bone structure no longer visible. Animal's movement may be impaired.


Score = 1


Score = 2


Score = 3


Score = 4


Score = 5


Score = 6


Score = 7


Score = 8 or 9

services per conception.

Pre-calving BCS has a tremendous influence on reproductive efficiency. The target BCS is 5-6 at calving. As pre-calving BCS decreases, the number of days from one calving to the next increases in beef cows. Cows with lower pre-calving BCS reproduce less efficiently because their postpartum interval (PPI) is longer. Cows need to conceive early in a spring breeding season, before periods of heat stress begin. When cows are wintered on low-quality hay, they generally lose body condition and may not regain it quickly enough to conceive before periods of heat stress occur (usually late June).

Table 8-10 shows the results of several trials in which the effects of BCS at calving were studied. In all instances, cows scoring less than 5 at calving time had the lowest rates of return to estrus and the lowest pregnancy rates.

Maintaining BCS of cows after calving also affects reproductive efficiency. Cows that calve in moderate body condition need to be fed to

Table 8-10. Effect of body condition score at calving on reproductive performance.

	Body Condition at Calving		
	4 or less	5	6 or more
Trial 1			
Percent in heat within 80 days after calving	62	88	98
Trial 2			
Percent pregnant after 60 days	69	80	- - -
Trial 3			
Percent pregnant after 60 days	24	60	87
Trial 4			
Percent pregnant after 180 days	12	50	90
Trial 5			
Percent pregnant after 60 days	70	90	92

Adapted from Herd and Sprott, 1986. Body Condition, Nutrition, and Reproduction of Beef Cows. Texas Agricultural Extension Service B-1526.

Table 8-11. Effect of change in BCS after calving on PPI.

BCS	PPI (days)
Lost	60
Maintained	32
All cows	43

maintain their body condition in order to obtain a short PPI. Data shown in Table 8-11 illustrate the importance of maintaining condition (feeding more) after calving. Cows that had been maintained at a BCS of 5 were allowed to lose condition or were maintained at that level. Those that lost condition required 60 days to return to estrus compared to only 32 days for those that were maintained at a BCS of 5.

Simply stated, cows need to be managed so that they maintain a BCS of 5 or greater from the pre-calving period (usually during the winter) through rebreeding to optimize reproductive success. Additionally, for spring calving cows, do not move cattle to pasture so early in the spring that they lose body condition due to low forage availability.

Table 8-12. Example diets for beef cattle at different production stages.

Dry cow, mid-gestation (1,300-1,400 lb.)	Low to medium quality pasture
	30 lb. average quality fescue hay
	20 lb. average quality fescue hay + 20 lb. corn silage
	24 lb. corn stalk residue grazing + 3 lb. soyhulls + 2 lb. dried distillers grains
Dry cow, late gestation (1,300-1,400 lb. last 60 days before calving)	Vegetative grass pasture
	25 lb. average quality fescue hay + 1 lb. corn gluten feed + 4 lb. soyhulls
	20 lb. average quality fescue hay + 23 lb. corn silage + 1 lb. corn gluten feed
	25 lb. average quality fescue hay + 12 lb. distillers condensed solubles (syrup)
Lactating cows	High quality pasture
	25 lb. average quality fescue hay + 6 lb soyhulls + 3 lb. dried distillers grains
	16 lb. average quality fescue hay + 30 lb. corn silage + 4 lb. dried distillers grain
	25 lb. average quality fescue hay + 16 lb. condensed distillers solubles + 2 lb. soyhulls

NOTE: 1,350 lb. cows assumed to be in good body condition at the start of feeding period. No mud or rain was considered which would increase energy intake to compensate for increased maintenance requirements.

Feeding the Cow Herd during Winter

Feed costs represent the greatest single expense in producing a calf for marketing from the cow herd. However, the nutritional program should not be so limited that production is negatively impacted. Managing to keep feed costs low and production levels high will improve your profitability.

The goals of a winter feeding program will vary by calving season. Most beef herds with a controlled breeding season calve in the spring or fall. Providing sufficient energy and protein during late gestation is critical to set the calf up for success. Adequate nutrition during gestation ensures calves are vigorous at birth. Strong calves at birth will consume colostrum within the first 12 hours of birth providing passive immunity. Research illustrates that thin cows and first-calf heifers produce less colostrum with fewer antibodies than mature cows in ideal condition. Cows need access to a high quality diet to support their genetic milk production potential supporting the growth of the suckling calf. Additionally, spring calving cows should be in good condition at calving in order to return to estrus soon after calving and conceive before periods of extreme heat.

The goals for fall calving herds are similar, but cows rebreed in December/January avoiding heat stress related challenges. Cows calving late September through October can graze accumulated or stockpiled fescue during peak milk production and ideally through breeding. Stockpiled fescue may meet or be slightly below the nutritional needs of beef cows at peak limiting body condition loss while most hay is lower in quality leading to greater tissue mobilization. By the time the calves are 3-4 months of age, forages and other feedstuffs play an important role in providing the nutrients to support growth. Calves may require supplemental feed during later winer and early spring. Often during this period pasture forages are not normally available. Calves must rely on the hay offered which is generally too low to meet their needs and creep feeding higher quality forage or a grain mix may be provided to increase weaning weights.

As shown earlier, cattle in different production stages have different nutrient needs. You can better meet the nutritional needs by separating the herd into groups based on their stage of production. This also makes the most efficient use of feed resources. As an example, feeding the lower quality hay first to spring calving cows when the cows are in a production phase of being dry, mid-gestation and feeding higher quality hay later during late gestation and early lactation better matches the forage to cow nutrient needs. In contrast, fall calving cows should be provided the best quality hay first and lower quality hay later as milk production falls with higher quality hay creep fed to calves later in winter.

Since winter feeding is a major expense, ways of lowering costs without compromising performance should be considered. Some things to consider are:

- Forage testing and supplementing according to needs
- Shortening the winter feeding period by extending the grazing season through use of annual forages
- Reducing dependence on stored feed through the use of stockpiling forages
- Making planned, volume purchases
- Considering alternative feed
- Minimizing equipment costs (i.e. total mixed ration wagons for small herds)
- Culling open or poor-producing cows prior to winter
- Reducing feeding losses
- Harvesting hay at the proper stage of maturity

Before winter, give yourself time to make decisions. Estimate your winter needs early in the year. Hay is cheaper near harvest time compared to the time when everyone is feeding and shortages exist. Table 8-12 shows sample rations for various classes of beef cattle. To estimate the amount of winter feed you will need, multiply the appropriate ration by the average number of anticipated days to feed the diet and then by the number of cattle to be fed the diet. For example, if the average length of winter is 120 days and if 50 cows are overwintered, then multiply the corresponding feed intakes

by 6,000 (120 d X 50 hd = 6,000 feeding days). Lastly, multiply the feeding days times the amount of feed needed per animal daily (6,000 feeding days X 40 lb hay = 24,000 lb hay),

Dealing with Cold Weather

You also must consider the challenges of cold winter weather. Cold increases the rate at which feed passes through the digestive tract. This is both a positive and detrimental physiological change. Quicker passage leads to greater intakes. For high quality feedstuffs that are rapidly digested in the rumen this can increase energy intake to help compensate for the greater maintenance energy needs. Yet, less time in the digestive tract means decreased digestion of fibrous material. In other words, lower-digestible, fibrous feed yields even fewer nutrients during extreme cold temperatures.

Cold weather increases nutrient requirements, especially for energy. As wind chill drops below the lower critical temperature for the animal, the amount of energy required for maintenance increases. Thus, prolonged cold periods decrease the digestion of nutrients from feed and increases the animal's energy intake needs. Producers can cope with long periods of cold by increasing the quality of the forage being fed or by supplementing with concentrates.

Certain nutrients, such as water, require special attention in winter. If water intake is limited by freezing or cold weather, feed intake decreases. Producers must keep water sources open in the winter and, if possible, above 40°F for maximum feed intake.

Previously vitamin A was discussed as an essential vitamin often needing supplementation. This is especially true in winter. Cows consuming high-fiber, low-quality hay and coming out of a hard winter will have used most of the vitamin A from their body stores. Supplement the vitamin in the winter by either feeding or injecting to maintain body stores.

One of the most effective management practice to minimize supplement feed expenses is to test your forage to determine the energy and protein content. This information can then be used to develop a strategic and cost effective supplement program. If a supplement is needed, do not purchase on price alone. Instead, purchase a supplement that will meet the nutritional needs first then find the most cost effective supplement option. This means pricing supplements on a unit of energy, protein basis as well as factoring in feeding convenience, labor, and feeding equipment needed.

Nontraditional Winter Feeding

Forages form the basis of the nutrition program for beef cattle. They are grown on the farm, require little out-of-pocket expense, and generally are the most economical source of nutrients for beef cattle. Situations do occur in which producers should consider alternative feed sources, however. Drought may limit forage production or, in some situations, excessive moisture may delay hay harvest such that quality of forage is severely reduced. In some cases, prices of certain commodities may be low enough that it is more economical to use them in place of forages. Regardless of the situation, the most important factor is to meet the nutrient needs of cattle. Which feeds are used to meet these needs is of less importance than the fact that they are met.

When alternatives are not available on the farm, purchased feeds must be considered. Hay can be purchased, but feeds that are high in energy content such as grains or certain commodity feeds are generally cheaper per unit of nutrient than hay. If forage supply is inadequate for the entire feeding period, you can substitute concentrates for forages if this is more cost effective than buying additional hay. One pound of corn contains approximately the same amount of energy (TDN) as 2 pounds of medium-quality hay.

When hay is in short supply leading to higher than normal prices, grains might be a cheaper source of nutrients. It is important to understand that there is not a 1:1 reduction in forage intake when supplements are offered. Commonly, feeding 2 pounds of supplement will only result in a reduction of 1 pound of forage intake. Therefore, forage must be limited. Limiting forage intake access by unrolling the amount of hay needed daily, limiting the time of access of hay in a pen or field or using a feed wagon is necessary to control hay intake if the goal is to stretch forage supply when grains/commodity feedstuffs are being supplemented to replace hay.

Table 8-13. Limit-fed corn versus hay rations for cows (three-year summary).

Ration	Corn	Hay
Wt. loss lb.	-53	-72
Calf birth wt. lb.	102	96
Wean wt. lb.	634	613
Conception %	91	84
Average daily feed intake (lb.)		
Hay	2.1	30
Shelled corn	11.3	-----
Supplement	2.5	-----

Source: Journal of Animal Science 74:1211.

Alternative feeds are not always purchased feeds. Producers should first ask themselves whether there are other potential feeds available on the farm. For example, is there a corn or soybean crop on the farm that will make too little yield to justify harvesting as a grain? If so, chopping the corn as silage or rolling the soybeans as hay can be helpful for salvaging a drought-damaged crop. Some special considerations are necessary, however, when drought stressed forages are being considered for feed. Compared to normal corn silage, drought corn silage contains less energy and equal or greater levels of crude protein. The crude protein is mostly all in the non-protein nitrogen form in this drought stressed corn silage. To balance the protein in this silage, supplementation should be from plant-based sources to produce normal levels of gain and performance. In addition, it is important to read herbicide and pesticide labels to ensure there are no restrictions for use of the crops sprayed being considered for feed.

Cattle can be wintered safely if rations are limit fed as shown in Table 8-13. In an experiment at Ohio State University, large-framed Simmental cows were divided into two groups at the beginning of the winter feeding season. One group was provided free-choice access to round bales of hay, primarily orchardgrass and alfalfa. The second group was fed whole shelled corn and a pelleted protein supplement to meet NRC nutrient requirements. In all trials, cows fed whole shelled corn also received approximately 3 pounds of long-stemmed hay daily to ensure rumen health. For the grazing season, both groups were combined and grazed together for the remainder of the season.

Table 8-14. Limit feeding high-energy rations for growing cattle.

Ration	C.S. + Supplement	H.M. Corn
Head	40	40
ADG, lb.	1.94	1.94
DMI, lb.	13	9
F/G, lb. DM	6.69	4.65
DM digest %	65	88.6

Source: Journal of Animal Science 68:3086.

Based on daily costs, limit feeding high-energy rations to wintering cows was slightly more economical than free-choice hay feeding. Realize that in trials, cost savings was only relevant for the period during the study. One needs to be certain to utilize current feed prices to determine feed savings with alternative feeding programs. When considering differences in weaning weight and conception rate, limit feeding high-energy rations for wintering cows can be an alternative to winter cattle with free-choice hay feeding.

An additional benefit of limit feeding high-energy rations to growing cattle is shown in Table 8-14. Limit-fed growing cattle fed the high-moisture corn had 30% lower dry matter intakes compared to corn-silage-fed cattle. Gain was equal for both groups of cattle because ration digestibility and energy density increased for the high-moisture corn diet. A principle to understand is that as intake of high-energy rations is decreased, passage rate through the digestive tract is slowed and total tract digestibility increases. The cattle receive more nutrients out of each unit of feed. But this principle of limit feeding still provides adequate nutrients to meet nutrient needs when diets are developed by nutritionists for these feeding programs. This concept of limit feeding should not be interpreted such that cattle can be limit fed completely disregarding the nutrient requirements of the cattle.

Some producers may not be willing or able to manage the elimination of hay feeding with limit-fed high-energy rations. They may simply want to supplement some additional energy when hay quality is low or when there is some supply but not enough to last through the winter. In these cases, producers will commonly feed a few pounds of corn per day to the cows. This may not be the best decision due to a phenomenon known as associative effects of digestion. However, using corn can be utilized successfully when limited and the dietary protein is balanced to ensure sufficient DIP for the rumen bugs. Generally speaking, limiting corn to 5 lb. or less per 1,000 lb. of body weight will have minimal impact on forage digestion when adequate DIP is supplied.

Feeding Management During Drought

The effect that drought and the ensuing pasture shortage have on the beef herd largely depends on when the drought occurs. For example, if drought conditions occur in late spring and early summer (late May through July), production is decreased in both the current year and the subsequent one. Producers must deal with decreased weaning weights and understand that the rebreeding of the spring-calving cow herd is in jeopardy. Managing the cows for adequate rebreeding is a primary concern. If the same conditions were to occur in late summer, the cows should already be pregnant and the calves closer to weaning age.

These are mitigation options to consider when deciding what to do in a drought situation: weaning calves early, supplemental feeding of the cow herd, creep feeding calves, "stretching" the forage supply, marketing a portion of the herd, or implementing various combinations of these options.

Early weaning has been successfully used on calves as young as 35 days of age to encourage cows to cycle and rebreed earlier during periods of drought or when body condition is poor. Early weaning eliminates the nutrient needs for milk production, thus freeing up more energy for maintenance and reproduction. Removing the suckling calf also causes hormonal changes in the cow that stimulate estrus (heat). Weaning calves at three to five months of age is also a viable alternative when forages are scarce and milk production is low, but this is too late to assist early cycling. Weaning at 3-5 months allows for the cow to lower her nutritional requirements, reducing body condition score losses, and giving more time to regain lost condition on limited resources to help with the next breeding season, not the current one. Consider early weaning when cows are milking poorly, calf growth is below normal, and cows are likely to experience poor reproductive performance.

Before you wean calves early, make plans to handle the calves based on their age and the available feed supply. In some situations, you might need to sell early-weaned calves directly off the cow. However, this is not usually a good option since calves are lightweight and the market is depressed during a widespread drought. The long-term considerations might be more important than the present economic situation (that is, high feed prices).

The first two weeks are the most critical time in the early weaning period. Calves must overcome the stress of weaning and learn to eat and drink quickly. The first ration should be very palatable and high in protein and energy, since intake at first is small. Place calves in a small pen with shelter available. The feed bunk and water source should be accessible and easily recognizable to small calves. Place feed bunks perpendicular to fences, and allow water troughs to overflow to attract calves. Vaccinate all calves for blackleg and malignant edema.

Several commercial starter/conditioning feeds are available, or you can have feed mixed locally. The diet should be high in natural protein (13 to 15%) and energy (70 to 75% TDN), with adequate minerals and vitamins. It should also contain a coccidiostat.

Some problems to look for during drylot rearing of calves are respiratory problems, especially seven to 14 days after weaning; sorting of the feed, which can lead to founder; coccidiosis; and scouring. If calves become fleshy or scour, increase the roughage content of the ration or cut back on the amount of concentrate fed. Remember that early-weaned calves are started on a diet high in energy and protein and should be gradually changed to a grower-type ration as their intake increases.

Although early weaning is not recommended as a standard practice, it can be useful in times of drought when purchased feed may be more efficiently fed directly to the calf than to the lactating cow.

Kentucky research shows that weights at normal weaning time were 508 pounds for early-weaned and fed calves compared to 463 pounds for calves reared on dams that were fed. Early weaned calves

received a higher plane of nutrition from the feed than what calves left with the cows did to support additional gain. If supplemental feed for the cow herd had not been available during drought, early weaning or selling the calves would have been the only choices.

Feeding the cows is an option if early weaning is too drastic, requires too much management, or is not needed because an economical source of feed is available. The amount of feed needed varies with cow size, stage of production, and amount of feed being supplied from pastures. As an example, the nutrient needs of a 1,100-pound cow during the first three to four months of lactation could be met with 20 to 25 pounds of good-quality hay (minimum 55% TDN; 10% protein) with mineral/vitamin supplementation. Heavy-milking cows require another 3 to 5 pounds of grain. If cows are getting some portion of this from pasture, feeding can be reduced.

If the cow herd is still in the breeding season, it is desirable to supplement with good hay instead of "saving it for winter." Protein supplementation can help increase digestion and intake of poor quality roughage, but energy is the greatest need. Therefore, some grain or better-quality hay might be needed for high-producing cows. Vitamin A should be supplied in the mineral/vitamin supplement since it is likely to be lacking in "dried" forage (pasture or hay).

When pastures are short and the corn crop has little grain due to drought, producers frequently decide to green chop the damaged corn and feed it directly. This can be extremely dangerous. Drought-stricken corn fed as green chop, whether grazed or baled, carries a high risk of nitrate toxicity. Nitrate level in forage can be checked, but it changes constantly. The safest use of drought-stricken corn is to ensile it and wait six to eight weeks before feeding it. Although this does not help your immediate feed shortage, it will cause the corn stalk to lose 40 to 60% of its nitrate content and provide a safe feed for later use.

Sorghum and sorghum-cross plants used for temporary summer pasture are also potentially dangerous during drought due to their prussic acid content and nitrate accumulation. These plants should not be grazed during or shortly after drought periods when they are stunted or wilted.

Creep feeding (see below) may have extra merit during drought. When pastures are adequate and of good quality and cows are supplying plenty of milk to the calf, benefits may not be great relative to the added cost. However, when pastures are poor during a drought, the increase in gain should be greater.

Creep Feeding Beef Calves

Creep feeding is the practice of supplying supplemental feed to the nursing calf while excluding the cow from this feed. After a calf is 90 to 120 days of age, milk supplies only about 50% of the nutrients the calf needs for maximum growth. The other nutrients must come from the other feed consumed if the calf is to realize its genetic potential for growth. High-quality pasture is the best source of nutrients; if this is unavailable or inadequate, concentrate feed or high quality stored forages can be used for creep feeding.

Creep feeding the nursing calf increases rate of gain and weaning weight. Expect increases in gain of 0.10 to 0.50 pounds per day, though gain responses can be quite variable. One must determine if the increased rate of gain will be profitable. To do this, consider the conversion rate, or the pounds of creep feed needed to produce a pound of gain. Conversion rates may range from 3-18 pounds of feed dry matter per pound of gain. For high-energy creep feeds which is the most common strategy used in the fescue belt, use a 10 to 1 conversion rate as a general rule. In addition, the price per pound for heavier calves at marketing, price slide, needs to be considered when evaluating the return from creep feeding. Table 8-15 gives the cost of additional gain at various conversion rates and feed costs.

When making a decision to creep feed or not, it must be profitable or add value to the feeder calf. Generally, creep feeding is profitable under the following circumstances: long periods of dry weather or drought, poor milking cows, large numbers of first-calf heifers or very old cows in the herd, late calvers (such as midsummer), fall-born calves, only low-quality pasture available, and periods of low feed costs and high calf prices.

Table 8-15. Cost ($/cwt.) of extra gain from creep feeding.

Feed/ lb. Extra Gain	Feed Cost ($/cwt.)				
	5	8	11	14	18
6	30	48	66	84	108
8	40	64	88	112	144
10	50	80	110	140	180
12	60	96	132	168	216

Creep feeding may not be beneficial under these situations: high milking cows; abundant, high-quality pasture; high feed costs and low calf prices; weaned calves kept to yearling weights; and heifers kept as replacement females. Creep feeding can be detrimental to replacement females. Fat can be deposited in the mammary gland, permanently reducing the heifer's ability to produce milk. Creep feeding also can "mask" the presence of poor milking dams and may make performance records difficult to analyze. It is generally not recommended to creep feed heifers, however, fall born heifers with access to low quality forage can be creep fed a high protein supplement offered at a low level, 1-1.5 lbs, with minimal impact on future production.

Creep rations do not have to be complex, but they should be economical and palatable. No matter how good a ration might be, if calves do not eat it, they will not gain more. Creep must be kept dry and fresh in the feeders. Avoid finely ground feeds as dust is not desirable and increases feed refusals as well as possibly leading to respiratory distress. You can use wet molasses or distiller's dried grains to enhance consumption if needed. If consumption is not adequate, substitute wet molasses for 3 to 5% of the corn as well as to aid in reducing dust. If possible, process the grains by coarse grinding or cracking. However, grinding corn too fine can increase risk of digestive disturbances. Additionally, the slight improvement in efficiency may not offset the additional cost of processing the grain. Cracked grains are recommended when mixing with feeds that are in a meal form such as soybean meal, cottonseed meal, and dried distillers grains to avoid separation issues. Minerals and feed additives should be added in a form that minimizes separation. Use pelleted mineral products when not using coarsely ground grains.

Creep rations don't need to complex and can be made from readily available feedstuffs. An equal portion of soyhulls, corn gluten feed and shelled corn can be an example of a readily available creep mixture as would be a 75:25 soyhull: corn gluten feed mixture. Oats are a good feed choice for use in creep feeds as they provide some fiber as well as having rate of starch digestibility in the rumen lower they risk of foundering calves. A mixture of 50% oats and 50% corn has been a common creep ration for many years. Cottonseed hulls can also be used as a way to incorporate fiber into a self-fed ration but should be limited to 5-7% to ensure feed doesn't bridge in the feeder. Ground ear corn is a great energy source for creep diets as cob and husk provides fiber and lowers the starch level in the diet, but again minimize dust. A few example creep diets are listed in Table 8-16. It is important to realize that as calves reach 5-6 months of age, creep feed intake can approach 2-2.5% of body weight which can be excessive. Intakes may need to be limited if creep intake exceeds 1.5% by adding 3-5% salt to the mixture. Digestive upsets and nutrient imbalances are possible if creep diets are not formulated properly. High-quality commercial creep feeds are available, and you might find that purchasing these is your best choice.

Starting calves on creep rations is sometimes difficult. One of the best starting methods is to feed their mothers small amounts of feed for a few days prior to beginning creep feeding. The calf learns to eat with its mother and will transition to a creep feeder more readily. Locating the creep feeder near the area where cows spend time will increase the time calves spend in the creep feeding area promoting intake. Draping fresh, high quality hay over the edge of the bunk/trough may also attract calves to the feeder.

Limit-fed, high-protein creep rations have drawn attention recently. These types of creep rations may be useful with large-framed, rapidly growing calves that have greater than normal protein needs. The benefit can be increased gain without excessive fattening due to excessive energy intake. Soybean meal, cottonseed meal, dried distillers grains, or other protein sources can be mixed with salt to deliver the targeted level of creep. Often salt inclusion will need to be between 5-10%.

Table 8-16. Example creep diets for nursing calves.

	High Energy			High Energy, Limited	High Protein, Limited
Feedstuff	**A**	**B**	**C**	**D**	**E**
Corn	33.3	50	50	72.5	--
Oats	--	50	15	--	--
Corn Gluten Feed	33.3	--	--	--	--
Soyhulls	33.3	--	--	--	--
Dried Distillers Grains	--	--	25	--	--
Soybean meal	--	--	--	20	90
Cottonseed hulls	--	--	5	--	--
Liquid Molasses	--	--	3	--	--
White salt	--	--	--	5	10
Mineral*	--	--	2	2.5	--

Include mineral products according to the manufacturer's recommendation. Consider adding an ionophore to creep rations.

Monitor daily creep intake to be sure it does not exceed 1.5 pounds. Conversion rates should be no greater than 5 pounds of high protein creep to 1 pound of calf gain for this to be profitable.

Creep grazing is basically the same as creep feeding. The calf has access to higher-quality forage, while the cow does not. Control access with creep gates constructed so that calves can pass through but cows cannot (from 15 to 18 inches wide and 36 to 40 inches high), or raise an electric fence that permits calves to walk under it but restricts cows.

Feed Additives for Beef Cows

Feed additives are either nutritive or nonnutritive compounds that improve performance and/or feed efficiency or act as a disease preventative when consumed in feed. If you properly use feed additives, you can greatly improve the profitability of your beef cattle operation.

You have the responsibility to use feed additives properly. This means:

- Using the feed additive for its intended purpose
- Following the feeding guidelines and any warning statement on the label
- Storing feed properly
- Observing any withdrawal time when necessary

Most feed additives fall into one of six broad categories: rumen fermentation modifiers, antibiotics, hormone or hormone-like products, anthelmintics, buffers, and coccidiostats. Other products that are approved for use in feed but do not fit the broad categories will be discussed as general additives. Additives in each category that apply to the beef cow are discussed below.

Rumen Fermentation Modifiers

Rumen fermentation modifiers (which include the ionophores) alter microbial fermentation in the rumen, thereby allowing cattle to obtain more energy from the feed consumed. Products currently available are Rumensin® (monensin), Bovatec® (lasalocid), Gainpro® (bambermycin), and Cattlyst® (laidlomycin). These products are most commonly used for increased weight gain and improved feed efficiency for cattle fed in confinement or increased rate of weight gain for pasture cattle. Rumensin is also approved for increased feed efficiency in mature reproducing beef cows. All products have various label claims and are available in different forms of feed. Instructions for use of rumen fermentation modifiers are found on feed tags of commercial feeds that contain them. At the time of this publication, ionophores are not labeled for beef cows through a free-choice supplement product and must be mixed with at 1 pound of grain. There are free-choice products available for growing cattle, replacement heifers. Be sure you utilize products according to the feed manufacturers labeled directions.

Antibiotics

Antibiotics are generally added to the feed of growing and finishing cattle, but most may also be used with the beef cow when necessary. Antibiotics are used at for prevention and treatment of diseases such as the bovine respiratory complex, anaplasmosis, footrot, and pinkeye.

Use care when feeding antibiotics. Recommended levels give the desired results; too much can interfere with rumen function and actually decrease performance. Use of medicated feeds require a Veterinary Feed Directive (VFD). A VFD is essentially a prescription for the group of cattle which will receive the medicated feed.

Anthelmintics

Many anthelmintics, or dewormers, are available in feed forms. Dewormers are generally administered directly to the animal, but when animal handling is a challenge, feeding can be an acceptable method. Products may be mixed into a meal-type feed, or they are commercially available as cubes or pellets. Some products are also available in block form and as loose minerals. Check with a local feed or animal health dealer to find products available in your area.

Other Additives

Other products are approved as feed additives for specific purposes. These include products to prevent bloat when cattle are grazing lush legume pastures and fly-control products that act as growth regulators or as a larvacide (also available in feed forms). Direct-fed microbials and enzymes are showing continued growth in the market place. Be sure to follow the feeding guidelines with these and all feed additives. Follow the approved feed additive combinations and do not mix feed additives that are not cleared for feeding together.

Remember, feed additives are controlled by the Food and Drug Administration, and you have the responsibility to use these products properly. For more information contact your county Extension office or feed dealer.

Growing Beef Cattle Rations

Once calves are weaned, marketing decisions will determine the target performance levels. Desired animal gain will drive the ration fed to growing calves to meet the nutrient requirements. Feeder cattle that are to be held for a longer period of time (ie. 120-150 days) often have a lower target performance level than calves preconditioned for 45 days prior to marketing. Calves gaining 2.5 pounds per day will require greater energy and protein intake than calves gaining 1.25 pounds per day. A wide array of feedstuffs can be utilized to supply nutrients and develop rations for growing calves. Example diets for growing calves with a desired rate of gain of 2.5 pounds are shown in Table 8-17. Many factors can impact animal nutrient requirements and observed level of performance. Cold, wet haircoats, mud, heat stress, sickness, growth promotants, and other factors will influence performance.

Replacement heifers should be grown at levels to reach target breeding and calving weights. Recent discussions around target breeding rates is still somewhat split among reproductive specialists. Previously, recommendations for heifer weight at breeding was 65% of mature body weight while more recently research has suggested that this target may be lowered to near 55% with similar conception rates. The other consideration that is overlooked is that the target weight at calving is still recommended to be 80% of mature body weight to minimize dystocia. Thus, heifers lighter at breeding will require greater daily gain from breeding to calving without becoming fleshy and depositing excessive fat in the pelvic area.

Determining target rates of gains for replacement heifers requires knowing the expected mature weights. Estimates can be derived from using frame size or average weight of the mature cows in the herd adjusted to a body condition score of 5. If the average mature cow weight is 1,400 pounds, using a 65% target breeding

Table 8-17. Example diets for growing steers from 550-800 pounds using coproduct feedstuffs.

Ingredient	Lb., As-fed			
High-quality pasture	--	42.0	--	--
Dried Distillers grains	--	--	3	--
Corn Silage	--	--	23	--
Fescue Hay	6.5	--	4	9
Corn	3.5	2.3	--	2.5
Corn Gluten Feed	3.5	2.3	--	--
Soybean hulls	3.5	2.3	--	--
Bourbon whole stillage	--	--	--	67
Mineral	0.25	0.2	0.25	0.25
Total	17.25	49.1	30.3	78.8
% Dry matter	89	22.0	50.6	18.5
% Crude protein	11.6	12.8	12	13.6
% Total Digestible Nutrients	70.5	62.7	69	72.8
Est. ADG, lb/d	2.5	2.5	2.5	2.5

Note: Intake and nutrient requirements based upon the mid-point weight (675 lb.). Actual gains may differ based on environment, management, and health of cattle.

Table 8-18. Example diets for replacement heifers from weaning (550 lb) until breeding (900 lbs).

Ingredient	Lbs, As-fed			
High-quality pasture	--	65.5	--	--
Dried Distillers grains	--	--	2.5	--
Corn Silage	--	--	16	--
Fescue Hay	12.5	--	8	13.25
Corn	--	--	--	1
Corn Gluten Feed	2.5	--	--	--
Soybean hulls	2.5	2.0	--	--
Bourbon whole stillage	--	--	--	50
Mineral	0.25	0.3	0.25	0.25
Total	17.8	67.8	26.8	64.5
% Dry matter	89	22.4	59	23.4
% Crude protein	11.4	11.9	11.3	10.7
% Total Digestible Nutrients	60.5	60.5	62	65
Est. ADG, lb/d	1.5	1.5	1.5	1.5

NOTE: Intake and nutrient requirements based upon the mid-point weight (675 lb). Actual gains may differ based on environment, management, and health of cattle.

weight results in heifers needing to weigh just over 900 pounds at 15 months of age. If heifers weigh 550 pounds at weaning at seven months of age, the heifers must gain 350 pounds over the 240 days or have a performance level near 1.5 pounds per day. The challenge with developing heifers in Kentucky is forage quality changes over this eight-month period. Spring-born heifers weaned in the fall will be typically be offered fescue hay that may only support 0.5 pound daily gain through the winter requiring supplementation. Further, fall born heifers placed on grass in the spring may achieve 1.0-1.5 pounds per day gain on quality pasture alone but gains may be reduced pre-breeding if heifers are consuming mature fescue hay negatively impacting reproduction. Example diets for developing heifers are shown in Table 8-18. These diets should be considered with respect to the available forage base. Additionally, spot check heifer performance every 60 days to ensure heifers are gaining as expected and body condition heifers to ensure they will be near a 6 score at breeding.

A common mistake in developing heifers is that producers change their nutritional plane at breeding time to be similar to that of the cow herd. In other words, after heifers have reached 15 months of age they are introduced to the cow herd where the bull is for breeding. In some herds, the bull and heifers may be sorted back off at the end of the breeding season, but more commonly heifers remain with the cow herd. Heifers still are growing and are expected to reach 80% of mature body weight by calving. During late gestation, the fetus and mammary tissue development increases nutrient requirements above that of the mature cows. The nutrient requirements for bred heifers are shown in Table 8-19. Notice the increase in energy and protein requirements during the last trimester, particularly the last 60 days pre-calving. Managing replacement heifers on a "cow diet" often results in heifers being in a slightly negative energy balance pre-calving resulting in lower colostrum and antibody levels in colostrum. Additionally, heifers enter a negative energy balance during lactation leading to greater body tissue loss and negatively impacting rebreeding rates. Too often young females (2- and 3-year-olds) are open at the end of the breeding season due to insufficient nutrient intake from the available forages and being managed nutritionally as mature cows. To optimize reproductive success in young beef cows, manage them separately from the mature cow herd providing them a slightly higher plane of nutrition until after they wean their second calf.

Table 8-19. Recommended nutrient requirements for developing heifers.

	Months Since Conception								
	1	2	3	4	5	6	7	8	9
	NEm, Mcal/d Required								
Maintenance	6	6.3	6.5	6.6	6.8	6.9	7.1	7.2	7.4
Growth	2.1	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.4
Pregnancy	0	0.1	0.2	0.4	0.7	1.4	2.4	3.9	6.2
Total	8.1	8.7	9.0	9.4	9.9	10.7	11.9	13.6	16.0
	Metabolizable Protein, g/d Required								
Maintenance	295	310	318	326	334	342	350	357	365
Growth	130	129	127	124	123	123	123	123	125
Pregnancy	2	4	7	14	27	50	88	151	251
Total	427	443	453	466	485	515	561	632	741

Balancing Rations

Feed costs are the major component of the total cost of producing a feeder calf. Feeding cattle a balanced ration prevents wasting feed dollars and allows the most efficient level of production.

Ration balancing requires some basic information, including definitions of terms:

- Ration is the amount of feed an animal receives in a 24-hour period.
- Balanced ration is a ration that supplies the proper amounts and proportions of nutrients needed for an animal's growth, maintenance, lactation, or gestation.
- Nutrient composition refers to the amounts of specific nutrients contained in the feed. It is expressed as a percentage of the dry matter and may also be looked up in a feed composition table (see Table 8-7). These tables contain only average values; your feed will be represented only if it is average. For accurate information, you will need a nutrient analysis on stored forages; this can easily be done for a reasonable cost.
- Dry matter is the portion of feed left after all water has been removed. It contains the nutrients. Levels of dry matter intake for animals are shown in the requirement tables. These amounts are not all an animal will consume, but they represent an amount that can be consumed under normal circumstances. Feeds contain different levels of dry matter; therefore, it is desirable to balance the ration on a dry-matter basis and then convert the various feeds back to an as-fed basis.

A systematic approach helps in ration balancing. First, determine the nutrient requirements of the animal. This means you have to know the animal's type, size, and production level. Nutritional requirements are obtained from National Research Council (NRC) recommendations, which are generally available in computerized ration-balancing programs. Next, determine the feeds available for use. List their composition on a dry-matter basis from a composition table (such as Table 8-7) or a chemical analysis. Now you are ready to determine the amounts of the feeds necessary to balance the ration. This can be accomplished by using a computerized ration balancing program or, in some cases, by hand calculations.

Animals will gain more efficiently with a balanced ration. Consider using the Forage Supplement Tool for mature beef cows to estimate supplemental feed when feeding forages (http://forage-supplement-tool.ca.uky.edu/). The Kentucky Cooperative Extension Service can help you obtain forage analyses and ration balancing. Consider visiting with a nutritionist to develop strategic feeding programs for you beef operation.

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The End Product and Food Safety

Gregg Rentfrow and Paul Priyesh Vijayakumar

The End Product

The average American will consume more than 200 lb. of red meat and poultry this year. Approximately 60 to 65 lb. of that total will be beef, with ground beef as the most consumed form. In addition, Americans have more disposable income to spend on a wider variety of foods than ever before in our history and beef is no exception. Consumers can choose to purchase and consume beef from a variety of management systems (traditional, grass-finished, or organic) or beef from a specific breed or region of the country. Regardless of the type or form of beef consumers choose, they can be assured they are consuming a safe, wholesome food. Beef at grocery stores and/or eating establishments have gone through USDA Inspection, food safety plans such as the Hazard Analysis and Critical Control Points (HACCP), and come from an industry focused on food safety. Mistakes happen, but overall U.S. beef is the safest in the world.

The journey of beef from gate to plate, has not only focused on food safety, but beef farmers and meat processors also focus on providing a quality product. Beef quality can be described as desirable color and tenderness, along with superior flavor. American beef is considered to be the highest quality, most flavorful, and safest in the entire world. Each segment of the industry focuses on all of these parameters.

Beef Cattle Evaluation

Live animal evaluation is subjective, and even experienced cattle buyers will incorrectly evaluate the cutability and/or quality of an animal occasionally. Regardless, it is important for farmers to know the basic concepts of beef cattle evaluation. Comparing carcass traits (ribeye area, 12th rib fat thickness, marbling score) with live animal evaluations are key to becoming proficient in beef cattle evaluation.

Muscling and trimness are the traits to observe when evaluating live cattle. Muscling can be evaluated by standing behind the animal. Imagine how the body looks without the legs: Does the torso look round or like an inverted triangle? A round torso is an indication of muscle, whereas an inverted triangle is indicative of a light muscled animal. Then, look at the stance of the front and hind legs. Does the animal have a wide (heavy muscled) or a narrow stance (light muscled)? Furthermore, a full brisket and fat deposition around the tail-head are good indicators of fat cover. Again, from behind the animal imagine the torso without legs; does the body look like a square, flat across the top of the animal? A square, flat topped animal is an indication of a fatter animal. Finally, when the animal moves can you see the shoulder blades working and does the body appear to jiggle? These can be indicators of fat cover on the animal. Determining the difference between muscling and trimness takes time, patience, and practice, but consistent evaluation and comparing live animal evaluations with carcass measurements can help accuracy.

Converting Cattle to Beef

- Must be humanely handled and stunned (captive bolt gun or gunshot; 1958 regulation, revised 2002 Farm Bill)
- Exsanguinate (bled by cutting the throat and/or severing the major veins and arteries from the heart)
- Remove the head and present for inspection (mandibular lymph glands, tongue, etc)
- Removal of hide, feet, and viscera
- Carcass is split, trimmed free of contamination, weighed, washed, and enters the cooler
- Must be USDA inspected if meat is to enter commerce; custom slaughter is only a service provided to farmers and meat cannot be sold legally
- Last step prior to chilling in the cooler is microbial intervention (hot-water wash (≥180°F), steam cabinet, acid spray (lactic or acetic acid)
- Carcasses chilled for 24 to 48 hours by large processors (IBP, Cargil, etc.) before fabrication; small processors will chill/age carcasses seven to 14 days to maximize tenderness and quality

Again, red meat and poultry that enter into commerce, by law, must be inspected by the USDA-Food Safety and Inspection Service (FSIS). All aspects of the process must be inspected; slaughter, fabrication, ground product, and the various processed meats. There are no exceptions to USDA-FSIS inspection, regardless of size of farm or number of animals. Animals that are custom processed cannot legally enter commerce and is intended for private (owner of the animal) consumption.

Note: There are two forms of inspection, USDA (sold in all 50 states) and state (only sold in said state) inspection. State inspection has to be equal to or better than federal inspection. Kentucky does not have a state inspection service.

Aging and Beef Fabrication

Meat is approximately 70 percent to 75 percent water; thus the average beef carcass will lose between 2 percent to 5 percent of weight in the first 24 hours due to evaporative cooling. Large and very large processors will fabricate the carcass into primals and subprimals within the first 24 to 48 hours. The primals and subprimals are placed in vacuum bags and then boxed. It takes approximately 20 to 25 days for boxed beef to be delivered to a local retailer from the packing plant. The cuts will age inside the vacuum bag, referred to as wet aged beef. Aging allows the residual enzymes to breakdown the connective tissue and proteins to produce a more tender product. Small meat processors have the ability to allow the carcasses to dry age in the cooler, as a whole carcass, for seven or 14 more days. Dry aging also produces a more tender beef product but the flavor has been described as more intense, nuttier, or earthier. Due to the size of the industry, the vast majority of beef available in retail grocery stores is wet aged.

Beef cattle (live) yield only about 35 percent to 40 percent lean edible meat. During the conversion of muscle to meat (the hide, head, feet, blood, and viscera

have been removed), the difference between live weight and carcass weight is referred to as a dressing percentage. The average cattle will have a dressing percentage from 60 percent to 63 percent. From a conversion standpoint, a 1,000-pound live steer with a 62 percent dressing percentage will produce a 620-pound carcass. The 620-pound carcass will yield approximately 60 percent to 70 percent, depending on the amount of fat and bone removed from the carcass. In most cases, the 620-pound carcass will ultimately yield approximately 400 pounds of edible retail cuts with the majority as ground beef.

Retail Cuts of Beef

The four major primal cuts on a beef carcass are the round, loin, rib, and chuck. These cuts comprise approximately 75 percent of the weight of a carcass and account for roughly 90 percent of the carcass value (Table 9-1 illustrates the breakdown by weight and value of the primal cuts). The remaining 25 percent of the weight and 10 percent of the value come from the brisket, shanks, plate, skirt, and flank.

Steaks and roasts come from the primal cuts of meat. Each primal cut has its own characteristics in terms of tenderness, fat content, preferred cooking methods, and price. Retail cuts from the loin and rib are considered the most valuable due to tenderness and are suitable for any cooking method (grilling, pan frying, dry roasting, etc.). The round produces lean, affordable steaks and roasts that are intermediate in tenderness. The most economical cuts of beef come from the chuck. Retail cuts from the chuck have the most fat (marbling and seam fat) but are tougher due to being muscles of locomotion (larger muscle fibers and more connective tissue) and are more economical. Moist heat cooking methods (cook in liquid, stewing, etc.) work best for steaks and roasts from the round and chuck.

Table 9-1. Percentage of total carcass weight and value of each of the major primal cuts.

Primal Cut	Percent by Weight	Percent by Value
Round	23	29
Loin	17	29
Rib	9	11
Chuck	26	21

Adapted from Boggs and Merkel, Live Animal Carcass Evaluation and Selection Manual. Third Edition.

USDA Quality Grades

Meat inspection is mandatory to enter commerce; however, USDA Beef Quality and Yield Grading is a volunteer program, i.e. beef does not have to be graded to be sold. Quality grading is a predictor of palatability (flavor, juiciness, and tenderness), and ranges from USDA Prime (most desirable), Choice, Select, Standard, Commercial, Utility, Cutter, and Canner (least desirable). Beef from carcasses with superior quality grades (USDA Prime and Choice) are expected to be the most tender, juicy, and flavorful.

The ribeye is exposed between the 12th/13th rib juncture for grading. Maturity and marbling are the two factors used to assign a USDA Quality Grade. The following are descriptions of those factors.

Maturity

Tenderness is predicted by the age/maturity of the animal at the time of slaughter. As an animal ages, it develops more connective tissue and the meat becomes tougher. The maturity scores range is from A to E in the USDA Beef Quality Grading system, with A being the youngest (≈≤30 months old) to E as the oldest (≈≥96 months old). Maturity is further subdivided into degrees ranging from 0 to 90 in increments of 10. Maturity is determined by the amount of ossification of the thoracic vertebrae, color and shape of the rib bones (red, round ribs = younger animal, bleached, flat ribs = older animal), fusion of the sacral vertebrae (more fusion of the vertebrae = older animal), and color of the lean (darker lean = older animal). USDA Prime, Choice, Select, and Standard grade are intended for A and B maturity scores whereas, USDA Commercial, Utility, Cutter, or Canner are for the older C, D, and E maturity scores. Carcasses scored as A maturity come from steers or heifers that were intended to enter the food chain, whereas B maturity carcasses come from heifers and both A and B carcasses are fabricated into steaks and roasts interned for grocery stores and eating establishments. Maturity scores C, D, and E carcasses are cull breeding stock and due to challenges with tenderness these carcasses are used for ground beef and/or processed meats such as frankfurters, deli roast beef, jerky, etc. The following are estimates of the age of the animal at the time of slaughter for each USDA Maturity score.

Maturity	Age
A	less than 30 months of age at slaughter
B	30 to 42 months of age at slaughter
C	42 to 72 months of age at slaughter
D	72 to 96 months at slaughter
E	older than 96 months at slaughter

Marbling

Juiciness and flavor are predicted by the amount of marbling in the ribeye. Marbling degrees are determined by the amount and distribution of the flecks of fat within the ribeye. The marbling degrees range from practically devoid, traces, slight, small, modest, moderate, slightly abundant, moderately abundant, and abundant (Figure 9-1). Marbling is further subdivided into degrees ranging from 0 to 90, in increments of 10. Ribeye and loin cuts from USDA Prime carcasses will be sold to five-star, white tablecloth restaurants and higher end grocery stores, whereas cuts from USDA Choice and Select carcasses can be found in grocery stores and typical steakhouses. Blind taste test research indicates that as the marbling degree increases the overall flavor scores increase; however, consumers view USDA Prime as too fatty and expensive for purchase in grocery store meat cases.

Determining the Final Quality Grade

Once the maturity and marbling scores have been determined, a USDA quality grade is assigned, with younger, higher marbling degree carcasses receiving the superior grades (Prime and Choice). USDA quality grades can be further subdivided into high (+), average (0), and low (-), based on the degree of maturity and the marbling score.

USDA Yield Grades

USDA Yield Grades are lesser known, but still just as valuable. Beef yield grades predict the percentage of boneless, closely trimmed retail cuts from the round, loin, rib and chuck (Table 9-2). Beef yield (YG) grades range from 1 to 5; YG 1 carcasses

are very trim and heavy muscled whereas YG 5 carcasses are fat and light muscled. Official USDA yield grades are calculated to the nearest tenth (i.e., yield grade 2.7); however, only the whole number is stamped on the carcass (i.e., yield grades 2.0 to 2.9 are assigned yield grade 2; YG are not rounded up).

The components used to calculate the USDA yield grade are hot carcass weight, fat thickness over the ribeye at the 12th rib, ribeye area at the 12th rib, and percentage of kidney, pelvic, and heart fat. The regression equation to calculate yield grade is as follows:

YG = 2.2
+ (2.5 x adjusted 12th rib fat thickness)
+ (0.2 x KPH%*)
– (0.32 x ribeye area, sq. inches)
+ (0.0038 x hot carcass weight)

*KPH% is added to the equation as a whole number, rather than a converted percentage.

Yield grades of 1 to 3 are usually considered acceptable; grades of 4 and 5 are considered to be too fat and unacceptable. Even when yield-grade-4 and -5 carcasses are closely trimmed, there are large amounts of seam fat.

Collecting Carcass Data for Determining Yield Grades

Adjusted 12th rib fat thickness. The 12th rib fat thickness is measured a tenth of an inch, three-forths of the way down the ribeye (from the carcass split). The USDA grader will adjust the fat thickness to account for fat that was lost during hide removal or if they feel the amount of fat at the 12th rib is not representative of the entire carcass.

Kidney, pelvic, and heart fat percentage. Kidney, pelvic, and heart (KPH) fat is a dry fat sometimes referred to as suet, which is one of the first layers of fat deposited on the growing animal. KPH is subjectively determined as a percentage of the carcass weight and requires some experience and skill to accurately estimate. Keep in mind the carcass weight when determining a KPH% as the percentage of the same amount will be deferent in a 600 lb. vs. an 800 lb. carcass.

Ribeye area, square inches. The ribeye area/ribeye muscle (*Longissimus dorsi*) is measured utilizing a dot grid. Each square in the grid represents a tenth of an inch.

Hot carcass weight. Traditionally, the hot carcass weight is found on the carcass tag attached to the carcass.

Figure 9-1. Photo examples representing the minimum marbling requirement for the most common marbling scores with their corresponding USDA Quality Grade in parentheses.

Direct Marketing of Beef Products

Keys to success:

- Know your product(s).
- Know your consumer clientele.
- Know local and federal regulations.
- Develop the necessary infrastructure.
  - » Processing capabilities
  - » Distribution avenues
  - » Market segments
  - » Cooperative arrangements
  - » Cash-flow requirements

Local foods are extremely popular with consumers; the popularity of the Kentucky Proud program has exploded. Beef farmers may want to take advantage of this popularity and add direct marketing as part of the farms promotion. The following are basics that beef farmers may want to consider before direct marketing beef.

Step 1. Gather Information

Direct marketing beef from your farm can be an excellent way to promote your farm's brand, but it requires tremendous effort. The first step is finding a USDA inspected facility that is willing to work with you and help you with maintaining quality and labeling of your product.

The meat processors inspection stamp/legend must appear on all packages; thus the processor needs to know that you are direct marketing beef. In addition, good meat processors can be pre-booked for several months in advanced, which can make it difficult to create a consistent product flow. Beef farmers may want to pre-book several dates in advanced to ensure product flow.

Next, direct marketers need to determine where they are going to sell their beef. Traditionally, direct marketers sell at farmer's markets. The Kentucky Department of Agriculture oversees registered farmer's markets and roadside stands and they have guidelines/rules that must be followed to sell. These guidelines can be found at https://www.kyagr.com/marketing/farmers-market.html. Others may want to bypass the farmer's market and either sell off the farm or directly to restaurants/grocery stores. Contact the local/state health department (Kentucky Cabinet for Public Health) to understand the rules and regulations for selling off the farm. Finally, be cognizant when selling to restaurants and grocery stores as they want a consistent product and a consistent supply. This can be difficult for a small, family-owned beef farm.

Pitfalls of direct marketing:

- Possible upfront financial investment
- Cost/profit ratio of products
- Lack of marketing skills/plan
- Lack of processing infrastructure
- Liability insurance
- Regulatory requirements

Step 2. Evaluate Your Business Approach

Do you as an individual have the personality to deal with people on a business level? Are you a salesperson? Can you make the appropriate sales pitch to a wide variety of clients? Can you handle rejection? Can you deal with negative comments about your product? Can you manage employees (to be successful you may have to expand your workforce)? Are you capable of listening and responding to regulatory officials on a daily basis? How would you respond to consumer complaints? These are all issues requiring someone who has the ability to deal with a wide variety of people on different levels from production through marketing and sales.

Table 9-2. Corresponding percent closely trimmed retail cut from the chuck, loin, rib, and round for several yield grades.

Yield Grade	% Retail Cut[1]		Yield Grade	% Retail Cut[1]
1.0	54.6		3.5	48.9
1.5	53.5		4.0	47.7
2.0	52.3		4.5	46.6
2.5	51.2		5.0	45.4
3.0	50.0		5.5	44.3

[1] Calculated from the formula:
% retail cuts = 51.34
- (0.0093 x hot carcass weight)
- (5.78 x adjusted fat thickness, 12th rib)
+ (0.74 x ribeye area)
- (0.462 x percent kidney, pelvic, and heart fat).

The most challenges facing new direct marketers is being able to handle the aforementioned situations. Moreover, the biggest challenge to the aforementioned situations is that the direct marketer is dealing with these issues alone or as a family. This can create more stress or be more than what was initially considered. A key point to remember during your initial startup is that "the consumer is always right" and that everyone is your consumer, this can be difficult for farmers.

If you have the premium product and the personality to succeed in dealing with people, you are a prime candidate for direct marketing. This is when small details began to demand more attention to ensure success. Advanced planning and discussions with regulatory agencies and meat processors is a must prior to startup. By involving all necessary federal and state governmental agencies (i.e., USDA, FDA, EPA, public health, Department of Agriculture, etc.) you not only avoid potential costly mistakes but also exhibit your desire to properly follow regulations and produce a safe and wholesome food product.

Step 3. Develop a Marketing Plan

Issues such as consistent animal supply, processing capacity, labeling, product transportation, marketing, cash flow, etc., are extremely important aspects necessary for a successful direct marketing. It is important that interested parties develop a business and marketing plan prior to direct marketing beef. In many cases, this will be required for financial institutions if outside capital is required for startup. Not only will these plans assist you in developing your approach to direct marketing, but they may also prompt you to evaluate the way you do business in your other operations as well.

Furthermore, you have to decide what it is you want to achieve through direct marketing your product. Will this become your primary source of income? Many niche markets have grown to become major enterprises. Or are you looking to stabilize cash flow throughout the year to offset live animal price fluctuations? This is an important decision, as it will drive the efforts and input into your direct marketing program. Many university and government programs are designed to assist in the development of a marketing/business plan.

Step 4. Join with Other Direct Marketers

There is strength and security in numbers. The knowledge base is expanded, product flow is more consistent, the product becomes more consistent, etc., by combining efforts with other direct marketers. The group works toward a common goal in overcoming shortfalls in reaching customers, processing roadblocks, marketing efforts, transportation deficiencies, etc.

Sources of information:

- Networking with other producers
- Direct marketing/value-added conferences and workshops
- Kentucky Department of Agriculture
- University of Kentucky
- Local Cooperative Extension office
- Trade publications/associations
- United States Department of Agriculture-Agricultural Marketing Service

Summary

Plan, plan, plan! Prior thought and planning will be the keys to success. In addition, never give up. More than likely, someone before you has encountered a similar problem and developed a solution. The key to direct marketing is having a great consumer-demanded product and the perseverance to turn obstacles into opportunities.

Food Safety

It is estimated that around 325,000 people visit the hospital due to foodborne illness symptoms each year. Regulatory agencies have focused on prevention-based programs over the last 30 years to combat the different pathogens that could potentially contaminate meat products. Food safety is most important when it comes to food products. Simply cleaning, separating, cooking and chilling food properly can minimize or remove the chances of contamination and cross contamination. People handling meat products should wash their hands right, just before and after handling meat. Separating cooked meat, raw meat, and non-meat products such as fruits and vegetables from each other can prevent cross contamination. All beef products must be cooked to a minimum internal temperature of 145°, and ground beef products should be cooked to a minimum internal temperature of 160°. Temperatures should be measured accurately using a food-grade thermometer. Following the basic practice of keeping hot food hot and cold food cold is extremely important when handling beef products and cooked beef samples. Storing and refrigerating beef properly and quickly is not just good for food safety; it also ensures a higher quality beef product.

Meat sold anywhere in the United States must be produced, processed, and packaged in a United States Department of Agriculture (USDA) inspected facility even meat sold at the farmers market. Both the USDA and the Kentucky State's Food Safety Branch provide clear guidelines for how to ensure the safety of beef from the time it is harvested, processed, packaged, transported, and sold at the booth in the farmers market. These key areas include packaging, storage, labeling, and sampling.

Packaging

Perishables such as beef should always be safely covered to preserve the quality and to keep blood and juices beef from flowing onto other food. Beef should be sealed in packaging to prevent direct contact with ice or ice water. Water is a perfect medium to spread blood and bacteria to other foods and could cross contaminate non-meat products. Beef products that are going to be stored, marketed, and sold frozen should be packaged in a plastic bag or foil meant for freezing. Selling packaged beef at the famers market can be tough, consumers often like to see the different beef cuts and compare color, marbling, and weights. This could lead to consumers wanting to look at different packages in the cooler before they buy, which means the packages will be subjected to temperature variations from being taken out of the ice chest and handled many times. This also could disturb the vacuum packaging as packages are punctured and damaged when they are moved around in the cooler. A customer reaching into the cooler with dirty hands could contaminate the outside of a package, other packages in the chest and even the ice in the ice chest.

Vendors could use attractive signs and photos at the booth to allow consumers to visualize what kind of meat they are going to get if they buy. Effective marketing and communication could help avoid a contamination or foodborne illness incident. Kentucky Department of Agriculture (KDA) Farmers Market Manual Guidelines also say that meat vendors should contact the local health department to obtain a "mobile prepackaged retail sales permit."

Storage

Meat products should be stored frozen at 0° or refrigerated at 41° or lower, even during transport and at the farmers market. Especially during the farmers' market season, when outside temperatures reach 90° and above, beef products should be refrigerated or frozen within one to two hours. KDA's guidelines state that vendors should avoid the use of Styrofoam chests and use a plastic cooler or ice chest instead. Ice used in the ice chest or cooler should not come in direct contact with meat, nor should the meat be allowed to float in ice water. Vendors should also have ways to keep water from coolers from draining onto meat products or non-meat products for sale at the market. Vendors should pay special attention to meat stored at home before it is taken to the farmers market. Besides regulating the temperatures correctly, they should not store the meat for sale in the same freezer or refrigerator that has food for personal use. The refrigerator and freezer temperatures should be monitored all the time using a thermometer.

Each type of food has a different potential for cross contamination and should be kept separate. Each meat product should have its own clearly labeled cooler. For example, if you have a cooler for seafood, clearly label that cooler as "seafood cooler" to keep someone from accidentally storing beef in that cooler. Different species of meat, such as poultry or seafood, as well as raw and ready-to-eat (RTE) foods should be kept apart. Also, both raw and RTE meats should never be stored with fresh fruit and vegetables.

Most famers markets happen outdoors, where dust and insects can get onto the food, so vendors should cover their booth at the market with an overhead tarpaulin or a tent.

Vendors and workers handling all of the types of food in the booth could be a source of cross contamination themselves, so every booth/vendor should have their own portable hand washing station according to local health department requirements. Typically, the hand wash stations approved by health departments consist of a five or more gallon tank full of potable (drinkable) water, a nozzle dispenser, and a basin. The hand wash station should also have soap, single use towels, and a trash can.

Labeling

All beef products sold at the farmer's market must have the appropriate USDA seal or mark showing that the products have been through federal inspection. Vendors are also required to tell customers safe handling instructions, a use by date, the product name (ribeye, shoulder etc.) weight, the name and address of the processor, and the date meat was packaged.

Sampling

Offering samples is one of the best ways to attract long lasting customers. While presentation and quality of the beef product are very important, food safety remains the most important thing of all. If you plan to offer samples, know that KDA requires samples to be cooked at the farmers' market location. This

means samples can be brought precut or could be cut at the farmers market, but proper storage temperatures still have to be maintained. Cold samples must stay at 41° or lower, and hot samples should be kept at 135° or above.

Vendors handing out cooked or processed samples should try to cook beef only when it will be eaten quickly instead of sitting out. If it still has to wait for customers, vendors should monitor the temperatures so cooked product or cold product are not at the temperature danger zone for a long time. KDA Farmers market guidelines state that samples should not be kept out more than 30 minutes. It is recommended that vendors bring refrigerated samples since thawing samples could be a problem and water from thawed meat could get on other foods. A calibrated food grade thermometer is a must to make sure beef is cooked to the minimum internal temperatures recommend by the USDA-Food Safety Inspection Services (FSIS) below. To provide quality samples that are safe, vendors should let the meat rest for three minutes before it is handed out as samples (Table 9-3).

Table 9-3. Cooking food safely.

Product	Minimum Internal Temperature & Rest Time
Beef Steaks, chops, roasts	145°F (62.8°C) and allow to rest for at least 3 minutes
Ground meats	160°F (71.1°C)

Source: USDA-FSIS.

Approved hand wash stations and three compartment sinks are required to ensure staff handling the samples are doing it in a sanitary manner. Utensils, cutting boards, knives, and other food contact surfaces should be thoroughly washed and sanitized periodically. If a vendor also sells fruits and vegetables, three separate sets of utensils should be kept: one each for raw meat, cooked meat, and fresh produce. Proper presentation also means making sure customers only touch or pick up the sample they are eating.

KDA has stringent guidelines when it comes to marketing, selling, and sampling meat at an approved farmers market. KDA issues two types of sampling certificates: one for processed and cooked samples and the other for raw samples. The former requires a completed application, while the raw samples, specifically fresh fruits and vegetables, requires a Kentucky produce Best Practices Diploma. Both certificates are valid for two years. For more detailed information on these two certificates and guidelines for marketing, selling, and providing cooked/processed meat samples at the farmers market read the KDA Farmers Market Manual at http://www.kyagr.com/marketing/documents/FM_2016-2017KDAFMManual.pdf.

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Key Beef Cattle Marketing Concepts

Kenny Burdine

The beef market is one of the most fascinating in all of agriculture due to its size, complexity, and uniqueness. As of January 2021, there were more than 31 million beef cows in the United States with a little less than one million of them residing in Kentucky. The beef sector consists of many industries including cow-calf, stockering and backgrounding, finishing, processing, and retailing. Kentucky is largely a cow-calf state with a large stockering and backgrounding industry. Figure 10-1 provides a simplified visual representation of the industries within the beef marketing system.

The beef sector is comprised of many industries, and most cattle will pass through each of these (sometimes the stocker/backgrounding stage is bypassed and calves are placed directly on feed). While there are examples of vertical integration in the beef sector, it is much less prevalent than in other livestock species. For example, farrow-to-finish operations are the most prevalent type of operation in the hog sector and would essentially be a combination of the cow-calf, stockering/backgrounding, and finishing industries in the beef sector. The complexity of the beef system does create some challenges for information flow as signals from consumers must be sent back through several industries before reaching the cow-calf level. It is also worth noting that concentration increases as we move closer to the consumer. For example, a small number of companies control large market shares in the processing and retail industries whereas a large number of very small firms make up the cow-calf industry.

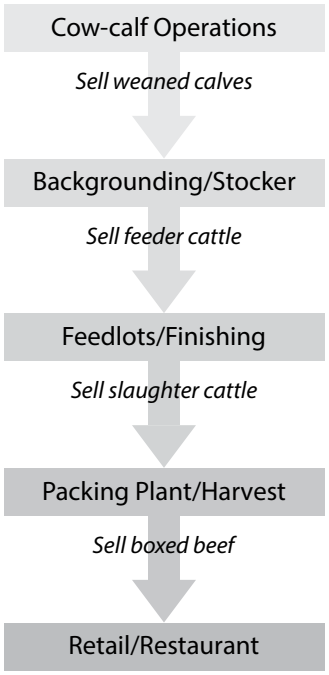

Figure 10-1. Overview of the beef marketing system.

Supply, Demand, and International Trade

Supply and demand drive prices for any commodity and the beef market is no exception. Typically, when one speaks of demand in the beef sector, they are speaking of domestic consumer demand for beef at the retail level. However, demand can also be estimated for fed cattle, feeder cattle, and calves, which is ultimately derived from the demand for beef. So, most discussions of beef demand start there.

Beef demand is a measure of consumer willingness-to-pay for beef products. The term willingness-to-pay is important because demand measures the relationship between beef consumption and beef price. An increase in consumer beef consumption doesn't necessarily represent an increase in beef demand if the increase in consumption was price driven. If consumers increase their consumption of beef while at the same time paying more for it, then that is a sign of an increase in beef demand. While, numerous factors have the potential to impact beef demand, three of particular importance are consumer tastes and preferences, incomes, and the prices of competing products.

Consumer tastes and preferences simply refer to changes in what consumers' desire. For example, beef demand decreased during the 1970s, 1980s, and the bulk of the 1990s largely due to changes in consumer tastes and preferences. Many consumers moved away from red meats during this time period. An example of a positive change in beef demand from changes in tastes and preferences would be the Atkins/South Beach diet trend that led to an increase in beef consumption for a segment of the market.

Incomes are another factor worth discussing as we think about beef demand. It is also important to understand that beef is not a single commodity, but rather a collection of a large number of products including high-end steaks, roasts, ground beef, and many other products. For most goods, consumers tend to increase their consumption when incomes are strong and this is likely the case for most of the beef market. Incomes are especially important in the case of beef as beef remains the most expensive meat of the three primary meats that Americans consume (beef, pork, and chicken). This tends to make beef more vulnerable to substitution during recessionary time periods when consumer disposal income is more limited.

Finally, consumer beef demand is impacted by the price of competing products. In the case of beef, its primary competition comes from two other primary sources of protein: pork and poultry. As the prices of competing products rise, beef prices become more attractive comparatively. For that reason, increasing supplies of pork and chicken are typically seen as a threat to beef demand. Increased pork and poultry production leads to downward pressure on the prices of those competing meats and makes beef look comparatively more expensive.

Beef supply is also an important piece of the price equation and is driven by many things. Certainly, the overall number of beef cattle on the market is a major factor affecting supplies. However, the amount of beef available is also impacted by slaughter weights, weather, international trade and many other factors. The quantity of beef on the market at any given time is estimated through cattle slaughter and beef production reports on a daily basis.

As one starts thinking about longer-term supply measures, discussion turns to cattle-on-feed reports and cattle inventory reports. Cattle-on-feed reports are survey based and are published monthly by USDA to estimate the number of cattle on feed in feedyards with capacity of over 1,000 head. This report not only includes an estimate of the total number of cattle on feed the first of each month, but also the number of cattle placed and marketed during the previous month. Cattle-on-feed reports can be used to provide estimates of slaughter cattle supply over the next several months.

Finally, cattle inventory reports are released by USDA-NASS twice a year and provide a more long-term estimate of supply. USDA estimates the total number of cattle and calves in the U.S. herd on both January 1 and July 1. This report also includes an estimate of the number of beef cows as of that date and an estimated size of the U.S. calf crop. The report can be used to gauge expansion or contraction of the U.S. cow-herd as it includes estimates of the number of heifers held for replacement purposes. Inventory estimates for individual states are released as part of the January 1 numbers.

A remaining factor to consider when discussing supply is the impact of international trade. Trade in beef products is a significant factor impacting U.S. beef prices. During 2020, the United States exported a quantity of beef equivalent to 10.8% of production, and imported the equivalent of 12.4% of its production. Imports were likely a bit higher in 2020 due to COVID-related production decreases in the spring of the year.

To put it simply, imports increase domestic supply and exports decrease domestic supply. However, trade is typically more complex than that, as we tend to export products that have higher values outside the United States and import products that have greater value in the United States. An excellent example of this is lean trim. Trim from U.S. packing plants is typically pretty high in fat. So, the United States imports a large amount of trim that can be blended with fattier trim in the United States to produce the blends of ground beef that are typically preferred by U.S. consumers.

Trade is also heavily impacted by relative production and consumption levels in importing and exporting countries, preferences of consumers, the value of the U.S. dollar, and any trade agreement or restrictions that might apply. While most trade discussion focused on beef trade, it is worth noting that trade in live cattle often occurs. While the United States exports very few live cattle, a significant number of live cattle come into the United States each year from Canada and Mexico.

Potential Market Outlets for Cattle

Beef producers have many alternatives as they consider marketing their calves. Key considerations include the expected value of the calves they sell by various methods, the amount of time they can devote to marketing, the security of payments received, and many other factors. The following section will briefly discuss four common marketing methods available to producers, but there are many options available.

Auction markets. Sale through auction markets is the most common marketing method in Kentucky. When producers sell cattle through auction markets they are paying a commission for a service and are outsourcing marketing to professionals. The auction market provides a platform for cattle to be sold by bringing multiple buyers together to bid on cattle in a competitive environment.

Auction markets are attractive in Kentucky for several reasons. First, auction markets are by far the simplest way to market cattle. All the producer really has to do is arrange for delivery to the market. This is especially attractive in situations where producers have limited time to devote to marketing such as in Kentucky where so many farmers have jobs off the farm. Secondly, most producers are small and unable to market tractor-trailer loads of cattle themselves. So, auction yards provide an environment where buyers can group cattle from multiple sellers and sort them into marketable load lots. Finally, auction yards are required to be bonded and use custodial accounting to keep operating money separate from money received for consignors. For this reason, payment is extremely secure and selling through a reputable auction market is virtually risk free in terms of receiving payment.

Internet/satellite sales. Internet and satellite sales are becoming more common across the United States. When selling using this method, cattle are typically offered for sale via video with a detailed description of the cattle in some type of sale catalog. This description, provided by the consignor, typically describes the cattle in terms of breed, color, frame, muscling, uniformity and other factors. It also usually includes details on weigh and delivery conditions so that buyers have a clearer picture of what they are bidding on. Multiple buyers can bid on cattle on site, or via the internet, in the same way they would bid on cattle that were physically at a sale barn. Internet/satellite sales are almost exclusively for cattle sold in tractor trailer loads.

One of the challenges of internet sales is the uncertain nature that exists with respect to many factors. For example, many cattle traits are only known to the extent that they are visible via the video or revealed by the seller via the cattle description. For this reason, cattle are typically offered for sale with a base weight and price slide. The base weight is the expected weight of the cattle at delivery and the price slide is the adjustment per 100 lb. for cattle that weigh over (or possibly under) their base weight. The price slide process may be best explained by using an illustration.

Price Slide Example

A group of calves is offered for sale through an internet sale and the consigner estimates they will weigh around 600 lb. at delivery. The consignor lists them with a base weight of 600 pounds and a price slide of $10 per cwt. For the sake of this discussion, let's assume this group of calves sell for $160 per cwt. If, at delivery, the calves actually weigh 700 lb., the price is adjusted downward by $10 per cwt., for a sale price of $150 per cwt. If the calves instead weighed 650 lb., the price would be adjusted downward by $5 per cwt for a sale price of $155 per cwt. Most slides only work in one direction and consequently do not raise the price of the cattle if they weigh less than the base weight. However, slides could be written to work in both directions in the sale catalog.

Direct sale of cattle. Many producers become interested in selling cattle directly to feedlots, backgrounders, or stocker operators. This is an option and some producers do it successfully. However, it is important that producers understand that direct selling of cattle requires much more effort on their part. They must first find a way to make contact with potential buyers which is a real challenge if cow-calf operators are not in an area where potential downstream entities operate. This is the case in much of the southeast if producers want to sell directly to feedlots. Beyond making initial contact, producers must become sales people and convince buyers to purchase the cattle they produced.

After actual sale considerations, producers choosing to direct market must deal with logistics and service for the cattle they sell. The producer has to arrange for delivery and weighing of the cattle, as well as collection of payment. They must also deal with issues that arise after sale such as poor performance. If cattle are sold through a stockyard, the producer doesn't get the call when problems arise. However, if the producer sells his/her calves directly, they will be the primary point of contact on those calves.

The final point to be made about direct sales is that arriving at a reasonable price for both parties is not always as easy as expected. When cattle sell through a competitive bidding process, the competition from other buyers tends to improve the efficiency of the pricing process. However, when pricing cattle directly to an individual, information becomes very important. It is not uncommon for one party to have better information about the market value of similar cattle or have a better estimate of what cattle weigh than the other party. For that reason, it is very important that producers selling direct have a solid estimate of the weight of the cattle they are selling and have a good understanding of the cattle market in their area. In order for direct selling to be more profitable for producers than auction markets, the net price of the cattle after delivery and shrink, must exceed the net price from the stockyards after delivery shrink and commission.

Direct-to-consumer sales. While Kentucky does not have a large cattle finishing industry or a large-scale meat processor, direct-to-consumer sales are a marketing option of which some producers are taking advantage. Kentucky has several meat processors that can harvest cattle on a custom basis for producers who wish to sell directly to consumers. USDA inspected plants can process cattle so that cuts of meat can be sold by the producer. Custom exempt meat processors, which are not USDA inspected, can provide custom processing services for the consumer.

Freezer beef is probably the most common form of direct-to-consumer sales. Producers can sell animals, or portions of animals (halves, quarters, etc.) directly to individuals. Freezer beef offers an excellent opportunity for producers to receive very good returns on a per-head basis, although considerable additional work (and time) is required. Direct sales also allow producers to capitalize on demand for local meat and production systems such as grass finished, natural, organic, and other attributes. Beyond freezer beef sales, some beef producers have been successful with farmers' markets, on-farm retailing, Community Supported Agriculture (CSA), as well as selling directly to wholesalers, restaurants, and retailers.

Factors Affecting Feeder Cattle Prices

While there are numerous factors that impact the value of cattle, this section will focus on a few factors of specific importance for feeder cattle. The first thing to remember is that the demand for feeder cattle is derived from demand for fed cattle. Key items that impact feedlot returns will impact what can be paid for feeder cattle and calves at any given time. Feedlots purchase feeder cattle today with the intention of selling fed cattle in the future and the primary cost of cattle finishing is feed costs. So, the two main factors impacting feeder cattle prices are the expectation of fed cattle prices in the future and corn prices.

Deferred fed cattle futures. Feedlots purchase feeder cattle today with the intention of selling fed cattle in the future. CME© Live Cattle futures provide the best indication of fed cattle prices in the future. For example, if feedlots are looking to place feeder cattle with the expectation that they will come off feed in December, they can use December CME© Live Cattle futures as an indication of price expectations. As the December CME© Live Cattle futures contract increases in price, feeder cattle prices will tend to increase as well and the reverse is also true. Recent work from Kentucky suggests that as deferred CME© Live Cattle futures change by $1 per cwt, feeder cattle prices change by $1.00 to $1.20 per cwt (Burdine et al., 2014).

Corn price. Since feed prices are the largest cost for cattle finishing operations, changes in corn price have considerable impact on feeder cattle prices. As corn prices rise, finishing costs increase and the price feedlots can pay (and remain profitable) for feeder cattle decreases. Similarly, as corn prices decrease, finishing cost decrease and feedlots will pay more for feeder cattle as they compete with one another. Recent work from Kentucky auctions suggests that for every $1 change in corn price, feeder cattle prices tend to move $3-$4 per cwt in the opposite direction (Burdine et al., 2014).

Calf prices are also impacted by feed prices, but there tends to be a seasonal element to this impact. In the spring of the year, most calves are placed into a grazing program by a stocker operator. For this reason, feed prices may have less impact on calf values in the spring. Calf values are more driven by the expected value of heavy feeder cattle in the fall and the cost of those grazing programs. By fall, when forage availability is no longer driving calf values, calf prices respond to feed costs very much like heavier feeder cattle. In fact, they are likely to be more sensitive to changes in feed price as they are smaller and likely to be on feed for a longer period of time.

Lot size. In addition to the derived demand factors of live cattle futures and corn price, many other factors impact feeder cattle prices. One of particular importance in Kentucky is lot size, which refers to the number of feeder cattle that are sold in a single group. Since so many of Kentucky's cattle operations are small scale, a large number of cattle move through auction markets in small groups. However, when feeder cattle are shipped to the major cattle feeding areas in the

west, those feeder cattle will be shipped in load lot quantities (50,000 lb.) to increase trucking efficiency. For that reason, prices for feeder cattle tend to increase as lot size becomes larger.

Figure 10-2 shows lot size impact on feeder cattle prices in Kentucky preconditioned feeder cattle sales from 2005-2013. Notice that price premium increases as lot size increases, but does so at a decreasing rate. Figure 10-2 suggests that once lot size reaches the load lot level, price benefit largely flattens out. However, the most important part of the curve to focus on is the far left, which shows price changes for extremely small lot sizes. The biggest benefit for increasing lot size by a small amount is for small lot sizes. Going from a lot size of 5 head to 10 head will have a much larger impact on price than going from a lot size of 50 to 55. The key point is that small producers can enjoy significant price benefit if they can simply avoid extremely small lot sizes. Selling cattle as singles, or in groups of two and three are the most difficult for buyers to deal with and will bring the lowest prices at auction.

For this reason, some auction markets may offer special sales where calves from smaller producers are co-mingled to make larger lots for sale. Kentucky's Certified Pre-conditioned for Heath program (CPH-45) is an excellent example of this as calves from multiple producers are managed under a uniform health program and co-mingled into uniform groups at the time of sale. Both factors tend to increase the value of calves sold through the program.

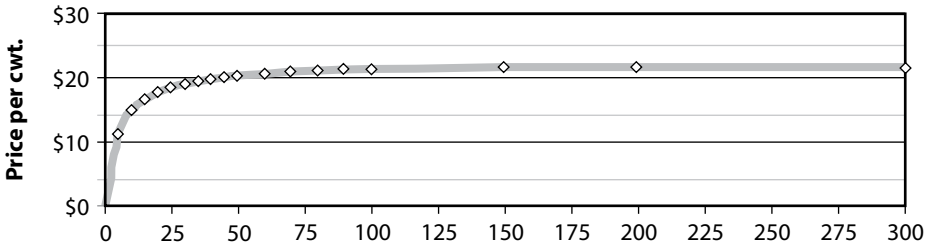

Figure 10-2. Lot size impacts on feeder cattle prices. Kentucky preconditioned feeder cattle sales (2005-2013) Source: Halich and Burdine, 2014

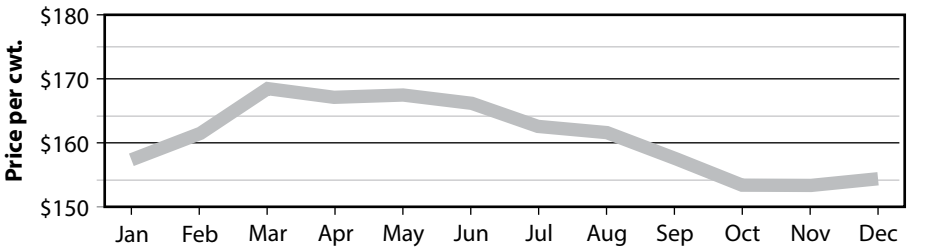

Figure 10-3. Average Kentucky auction prices (2010-2020) for 550 lb. medium/large frame #1-2 steers, $ per cwt. Source: USDA-AMS, Livestock Marketing Information Center, author calculations

Price Seasonality in Cattle Markets

Price seasonality refers to the typical pattern of prices within a year. Due to weather patterns, forage production, calving seasons, and other factors, there is a tendency for prices to follow similar patterns from year-to-year. While seasonal patterns don't always hold, beef producers should have a basic understanding of seasonality in the calf, feeder cattle, and cull cow markets.

Figure 10-3 shows average calf prices for 550 lb. medium/large frame #1-2 steers in Kentucky from 2010 to 2020. Note that calf prices tend to be highest in the spring and lowest in the fall for two primary reasons. First, spring calving herds are more common in the United States than fall calving herds so there are more weaned calves marketed in the fall of the year. Secondly, it is important to consider who is likely to bid on calves in the spring and fall and how that can impact their value. In the spring of the year, summer stocker operators are actively bidding on calves to place on pasture for the summer. Given the lower cost of gain on pasture, stocker operators are simply able to pay more for calves than feedyards and backgrounders that would be purchasing calves at the same time to place on purchased feed. As stocker operators compete for calves, they bid prices up in the spring as can be seen in Figure 10-3. In the fall of the year, stocker operators are not actively placing calves so they are more likely to be placed directly on feed in a feedyard or placed in some type of feed-based winter backgrounding program. The result is a lower target purchase price and hence lower calf prices in the fall of the year.

Seasonality for heavier feeder cattle is considerably different from what is seen in calf markets. The primary reason for the difference is that heavier feeders are not affected by grass demand in the same way that calves are as they will likely be placed directly on feed. Heavy feeder cattle values are driven by what can be paid for them given the expectation of fed cattle prices in the future (deferred live cattle futures) and the cost of finishing those feeders (feed prices). Seasonally, fed cattle prices tend to be highest in the spring and feed prices tend to be lower during the fall harvest time. For those reasons, heavy feeders tend to see their highest prices in the later part of the summer. To illustrate the seasonality of heavy feeders, Figure 10-4 depicts the average monthly prices from 2010 to 2020 for 850 lb medium and large frame #1-2 steers. Note the price peak in late summer and the lower prices in the winter.

While sales of weaned calves represent the largest revenue stream for cow-calf operators, they should not discount the importance of cull cow sales. Figure 10-5 shows cull cow prices for Kentucky from 2010 to 2020. Notice that cull cow markets behave somewhat similar to calf markets as they tend to peak in the spring/summer and reach their lows in early winter. Many will look at charts such as Figure 10-5 and consider holding cows through the winter in order to sell them at higher prices in the spring. However, this decision requires a budget analysis and is often complicated by the fact that cost-of-gain is typically very high for cows, and the value of the pounds added for cows is very low when compared to feeder cattle. However, Figure 10-5 does provide some insight as one considers calving seasons. Often the seasonal dif-

ferences in calf values are discussed, but the additional revenue from cull cow sales is not. In addition selling fall born calves on a stronger spring market, fall calvers also typically sell cull cows on a stronger spring market as well.

Cattle Cycles

Cattle cycles have been taught by many years by economists as a way to explain the cyclical nature of the cow-calf business. Cattle cycles can be thought of as long term changes in beef cattle inventory that tend to have implications for cattle prices due to the impact on supply. As producers experience times of strong profit, they tend to want to expand the size of their herds and as they experience periods of low profit, they want to decrease the size of their herds. While there is a lot of variation in cattle cycles, they typically last 10-14 years. Below are seven steps that generally describe cattle cycles:

1. Calf prices are strong and producers are making good profits. So many want to increase the number of cows they manage. They do this by holding back heifers to develop into brood cows.
2. The short-term impact of holding back heifers decreases the number of calves being sold and actually tends to push calf prices higher. This amplifies the expansion signal.
3. Over time, those heifers that were held are bred, calve, and wean calves. This results in a larger number of calves being sold each year. Eventually, this will put downward pressure on prices, holding other factors constant.
4. As the supply of calves rises, calf prices continue to fall and many producers will exit the cow-calf business or choose to decrease the size of their herds. They do this by selling more females.
5. The increased quantity of females being sold places additional downward pressure on calf prices, which amplifies the liquidation signal.
6. Eventually, the resulting smaller cow-herd leads to smaller calf crops and calf prices start to rise again, increasing profits.
7. Go back to Step 1.

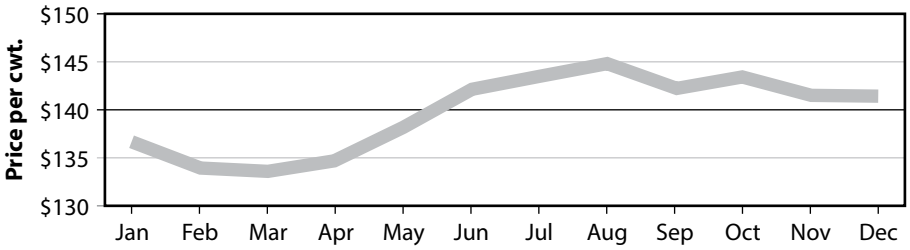

Figure 10-4. Average Kentucky auction prices (2010-2020) for 850 lb. medium/large frame #1-2 steers, $ per cwt. Source: USDA-AMS, Livestock Marketing Information Center, author calculations

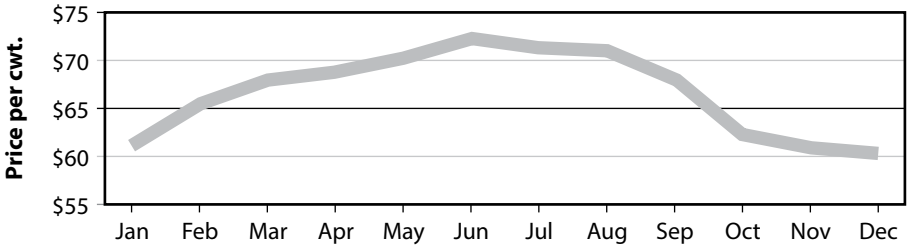

Figure 10-5. Average Kentucky auction prices (2010-2020). Cull cows—boning 80%-85%. Source: USDA-AMS, Livestock Marketing Information Center, author calculations

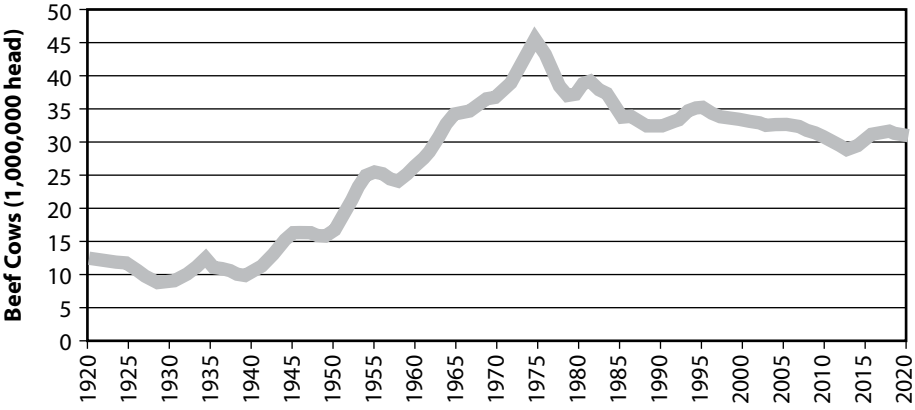

Figure 10-6. Jan. 1 U.S. Beef Cow Inventory, 1920-2021. Source: USDA-NASS

Figure 10-6 depicts U.S. beef cow inventory from 1920 to 2021, and clearly shows the cyclical nature of beef inventory during that time. Often when cattle cycles are discussed in an Extension setting, someone will ask the question, "So why do we keep doing this?" There is no easy answer to that question, but there are a couple reasons. The first is simply that producers respond to profits and there is no reason to believe that is going to change in the future. When profits are high, there is going to be temptation to expand. Secondly, the time lag involved is a major driver. Farms are not factories and cow-calf operators can't simply hire more workers and speed up the assembly line. It takes time to develop and breed heifers and it takes time for those heifers to produce and wean their first calves. So, there is considerable time lag between the start of expansion and when larger calf crops are actually seen at market.

While many have questioned the relevance of cattle cycles in recent years, it is likely that producers will continue to respond to profits as they always have and the associated changes in supply will impact prices. However, I do think producers should understand that given the increasingly volatile nature of cattle prices over the last several years cattle inventory is simply one factor among many that they should be watching. It is also generally advisable that producers keep cattle cycle dynamics in mind as

they make decisions about expansion and contraction of their herds.

Simply chasing prices (expanding when prices are high) may not be the best strategy for a cow-calf operation as it will typically be at least two years from when they make a conscious decision to expand until they actually have more calves to sell. Market dynamics are likely to be much different in two years. Producers should base their expansion decision on the expectation of profit during the productive life of the additional cows they are looking to add. Breeding cows are a long-term investment that should be evaluated using an eight to 12 year time horizon including expectations of calf values and production costs.

Sources of Market Information

For producers to be successful marketers, they need stay informed on the cattle market within which they operate. Fortunately, there are numerous sources of market information available for producers to take advantage of. As a starting point, producers should closely watch prices and market trends in the markets closest to them. The USDA Agricultural Marketing Service collects market data from most Kentucky auction markets. These reports can be accessed via the AMS website at https://www.ams.usda.gov/market-news/feeder-and-replacement-cattle-auctions#Kentucky.

Another very important publication that is published weekly by the Kentucky Department of Agriculture is the Kentucky Livestock and Grain Market Report. This report is sent out electronically each week and provides an excellent summary of Kentucky's livestock and grain markets. In addition to receiving the report by email, it can be accessed online at https://www.kyagr.com/marketing/documents/market-reports/AM_Livestock-Grain-Market-Latest-Report.pdf. Additionally, most auction markets have reports that they can make available to their clientele. Simply contact them for more information. Regardless of how market information is attained, know that information is becoming more and more important in today's cattle marketing environment.

Beyond local cash cattle markets, beef producers should learn to use the futures market as a source of pricing information. Futures market quotes are available through many sources, but they can be accessed online at the Chicago Mercantile Exchange website at www.cmegroup.com. CME© Feeder Cattle futures prices are cash settled to actual feeder cattle sales in a 12 state area. They are best representative of 700-900 lb. medium/large frame #1-2 feeder steers. Kentucky prices will be different from futures prices for cattle of the same weight due largely to transportation costs from Kentucky. This differential is typically referred to as "basis" in the cattle industry. While differences will exist, factors that affect the futures market will affect Kentucky prices similarly, so futures markets are an excellent source of market information.

Additional information on using the futures market as a source of pricing information and its potential as a risk management tool can be found in three publications—AEC 2013-01: *Using the Futures Market to Manage Price Risk in Feeder Cattle*, AEC 2013-03: *Using the Futures Market to Manage Price Risk in Feeder Cattle: Advanced Strategies*, and AEC 2013-AEC 2013-09: *Using the Futures Market to Predict Prices and Estimate Breakevens for Feeder Cattle.*

Acknowledgment

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Management Skills

Steve Isaacs

Management is an explicit process. It is often the difference between success and failure. The enterprise analyses of Kentucky Farm Business Management participants illustrate this point. Each year participating farms are classified into top-third and bottom-third categories based on net returns. Generally, the bottom third of livestock farms receives the same price as the top third for what they sell. The prices they pay for feed are often very similar for both groups. Given the same set of market and weather conditions, some farms make money, and some farms lose money. The difference between top and bottom farms is how they manage the resources they have.

Paradigms of Management

Our old farming paradigm is that if we work hard enough, we will be successful. A more recent paradigm is that if we do the right things, we will be successful. The current paradigm is that we will have to produce what consumers want and do it at a low cost to compete in a global market. Another paradigm is that we can produce a differentiated product (grass-fed, organic, natural) as opposed to a generic commodity for a specific market niche. All these recent paradigms demand more attention to marketing and management.

Management and Labor

Management differs from labor; however, they are not mutually exclusive. Working managers are generally the rule in beef cattle operations. Even when the same people in the operation provide both management and labor, it is important to recognize that labor (or hard work) alone will not assure success. Management is a distinct task that demands a time commitment from the leaders of the organization.

The danger lies in the tendency to believe that somehow management is not "work." To be "getting something done," we need to be doing some production task. This true story from the dairy industry illustrates this tendency.

A dairy farm family with a newly married son was evaluating the potential of expanding the farm to bring the son and his wife into the operation. The expansion would be expensive, in excess of half a million dollars. A day was set aside for a family meeting with a team of advisors including the lender, an area farm management specialist, and a dairy facilities specialist. They spent the entire morning around the kitchen table evaluating options, estimating costs and returns, and doing a "what-if" analysis to determine the riskiness of their decision.

A few days earlier the farmer had agreed to sell a load of hay to a neighbor. He had told him to come over around noon and he would load him up. A truck and trailer pulled into the farmstead about lunchtime, and the farmer headed out the back door to meet the neighbor. The neighbor greeted the farmer with the well-worn expression, "What are you doing sitting in the house? You can't get anything done sitting in the house!"

The time spent "in the house" that morning was arguably the most important time in the lives of two families. The strategic planning decisions they would make that day would set the course for the long-term future of the business and all the current and future family members. They *did* get something done "sitting in the house." They were planning for their future.

Defining Management

There are almost as many definitions of management as there are managers. Here are some examples:

- Management is determining what needs to be done and achieving results.
- Management is the practice of making rational decisions for allocating scarce resources to satisfy goals in a risky environment.
- Management is the ability to recognize, organize, execute, and evaluate.

Management is often defined along functional lines. The functions of management can be identified as planning, organizing, staffing, directing, and controlling (Figure 11-1).

Let's examine each of these five functions.

Planning

Planning is the development of the mission, goals, and tactics that will set the course for the business. Estimating costs and returns is part of the planning function. Planning includes data collection, problem solving, and decision making. Identifying, diagnosing, and prescribing solutions for problems are a part of the planning process. Identifying problems is the easy part of the planning function. Identifying opportunities is just as important. Decision making is also part of the planning process, and good managers use good decision-making RADAR. They can **R**ecognize, **A**nalyze, **D**ecide, **A**ct, and take **R**esponsibility for their decisions.

Organizing

Organizing is the function of establishing a business framework and defining the duties, responsibility, and authority of each position. Complex institutions or businesses will often have an "org chart" to define the structure, responsibilities, and chain of command within the firm. Even simple operations like small farms can benefit from evaluating their organizational structure. A farmer at a management workshop drew an "org chart" of his one-man operation. He drew a tree-shaped chart with various jobs and responsibilities on his farm and put his name in every box.

Even one- and two-person farms will often have "side-stream" positions that will be filled by people outside the business like veterinarians, accountants, and farm input suppliers.

Some of the most complex and often poorly defined farm business organizations are family operations. As multiple-entity or multiple-family operations become more prevalent, it is important to

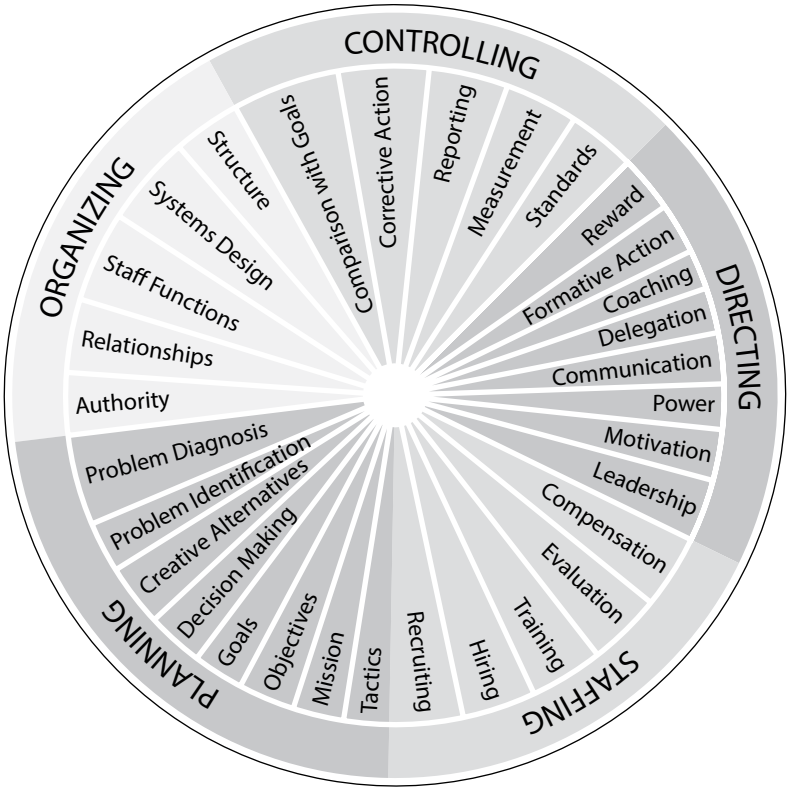

Figure 11-1. Five functions of management.

define areas of responsibility, chain of authority, and channels of communication.

One family operation at a management workshop drew four boxes for the four family members. Communication lines connected each member to the other three. The lone hired worker was outside the circle with a line drawn to him from each family member. The simple act of drawing the chart revealed to the family why their hired worker was often confused and frustrated.

Staffing

Staffing includes having adequate and capable human resources in place to perform all the tasks necessary for the farm to function properly. Staffing includes recruiting, hiring, training, evaluating, and compensating employees. This logically includes hired labor but will also include paid and unpaid family members. Many beef operations are small enough to provide labor internally from family resources. As farm sizes increase, more farm managers discover the need to develop skills in human resource management.

The process of finding the right person for the job, getting them hired at a fair wage, and training them to do the job is one of the most difficult tasks many managers face. Managing cows, crops, and machinery often seems simple when compared to the complexities of managing people.

A real barrier to farm growth comes at the point where operator and family cannot provide all the labor for the farm. Breaking through that barrier can open the path to growing the business. This step requires a manager who is willing to hire and train others to do some of what they have been doing. It requires delegating responsibilities and a willingness to accept and acknowledge the successes (and occasionally the failures) of others. An investment in a human resource management workshop would be a wise expenditure of time and money for any farm manager who hires labor.

Directing

Directing involves coordinating, leading, and motivating all the members of the business, including yourself. Coordinating the activities of the farm is closely related to the planning function. Coordinating the staff (even if it is only one) to complete the activities is closely related to organizing and staffing functions. Directing integrates these functions into the leadership and motivation elements that are often present in successful businesses and institutions.

Although hundreds of books have been written on the topic, there are, unfortunately, no easy formulas to follow to successfully lead and motivate people. Managers who are successful at the directing function are almost universally good communicators. They are also highly motivated themselves. They are also successful at sharing their vision with others in the business, both family members and employees.

Controlling

Controlling is the function of management that involves measuring and reporting data, comparing results to standards, and taking corrective action to remedy problems revealed by the analysis. Controlling includes record keeping, but it is more than that. Complete and accurate production and financial records are common on well-managed farms. Perhaps, more importantly, they are used as the basis for decision making.

Top managers access, assess, and use information. They use on-farm data to determine costs of production and to help identify ways to lower costs.

A key element of the controlling function is to compare results to a predetermined standard (a goal). Did the "plan" lead to a successful outcome? If not, why? Using data to describe what has happened is the key to developing a plan to improve performance. The controlling function provides an important feedback loop into the planning function.

The five functions of management are integrated components of a larger process. They can be discussed and explained separately, but they are practiced in unison. They are also practiced in the context of producing beef cattle. They can be illustrated in the management wheel, where the five functions are segments of a wheel with activities in each function representing spokes of the wheel. Like a wheel, all the spokes are important, and taking out any spokes can result in a bumpy ride.

The Planning Pyramid

Planning is the ongoing process of developing the farm's mission, goals, and tactics to focus activities toward the most productive and rewarding results (Figure 11-2).

The **mission** is the foundation of the business. It is why we do what we do. It can define our purpose. It is the answer to the question, "Why do I have beef cattle?" The mission provides the base for everything we do in the business.

Goals are specific statements of what we would like to accomplish. Goals are the things we would like to achieve to fulfill the mission of the business.

Tactics are the things we do every day to make the business run. Tactics are the "doing something" of the business. Most of our time on a farm is taken up with the activities that we do every day: the feeding, calving, planting, and harvesting. The focus of all the tactics should be on reaching the goals to fulfill the mission of the business.

Mission

Mission statements provide a foundation for effective leadership and efficient management. A good mission statement clearly and concisely defines a business, a person, or an organization. For a farm business, the mission statement describes:

- What the business is
- What the owners are trying to accomplish
- What their values are
- Where the farm is heading

Mission statements provide those involved in their creation with a vision of the future and a basis for strategic, long-term planning. Even on a daily basis we should ask, "Is this included in our mission statement?" Usually this question is asked, "Why are we working so hard?" These questions deserve an answer, and the mission statement is the tool to give that answer.

Few farm businesses have written mission statements, but those that do almost universally think that they are a good thing. Developing a mission statement helps everyone in the business understand why the farm exists. One workshop participant who completed a mission/goal assignment reported, "My husband and I have farmed together for 38 years, and last night is the first time we've talked about things like this."

Getting started is often the hardest part of developing a mission statement. Answering the following three questions will help "prime the pump" and get the process started. List four short answers to the first two questions.

1. What's important to me?

List four short answers.

_____

_____

_____

_____

These things are your core values. They are the things that you hold true and dear. These will often be highly personal. These are your values, so they should be personal. In a family operation or business, they should be shared values.

2. Why do I have this business?

List four short answers.

_____

_____

_____

_____

Answers to this question are your objectives. Objectives are general statements of what you would like the business to be like in five, 10, or 15 years. This should describe the position your business will have in the community or industry. It will describe your strengths and will give you an idea of what rate of growth you expect for the business.

3. How would I describe my business?

In a sentence or two, describe your business in terms of what products or services you produce. This could refer to the breed or class of cattle you produce and could include other products you produce on the farm.

_____

_____

_____

_____

Figure 11-2. The planning pyramid.

To complete the mission statement, take the information from these three questions, and write a draft that summarizes what you put down. Put it aside and let it ferment for a day or two. Share it with others in your family or business. In family operations, this should be a shared mission, so solicit and heed input from family members. Finalize a draft of the mission statement. Type it or write it in a format that can be displayed. Frame it and display it in a prominent place where you will see it regularly and often. Use it daily to answer the question, "Why are we doing this?"

Hundreds of participants in Master Cattleman and Management first workshops in Kentucky have written mission statements. Not one has reported it to be a wasted effort. Many nonfarm businesses and most large companies have clearly defined mission statements. Here is one mission statement from a Master Cattleman workshop participant.

> *Our farm is a family-owned and -operated business that depends on the teamwork and dedication of each and every member of our family for success. We strive to raise our children in a positive environment focusing on respect for the land and the animals. Our goal is to produce outstanding animals both for the commercial market as well as personal satisfaction. We operate our farm based on a code of honesty and integrity and hope to leave a legacy for our children to enjoy.*

Goals

Goals are specific statements of what you want your business to look like in the future. The oft-misquoted Yogi Berra was reported to have said, "If you do not know where you're going, how do you know when you get there?" Goals give us a specific target to strive for. Good goals are SMART goals. SMART is an acronym for **S**pecific, **M**easurable, **A**ttainable, **R**elevant, and **T**imed.

"Heavier weaning weights" is a good objective, but "a 575-pound average weaning weight" is a specific goal. Lower death loss, better calving percentage, and more leisure time are all worthy objectives, but they are not SMART goals. Objectives are general statements; goals should be specific and measurable targets to achieve. And they should be attainable. Retiring by age 40 is a specific, measurable goal but may not be attainable for most of us.

All of us have multiple goals, and reconciling conflicting goals is difficult. Do our goals relate to the overall mission we have established? Relevant goals help direct the business toward fulfilling the mission.

Finally, goals should be timed. Set a date when you would like to reach each goal. Or, at least, establish a time frame of short-term and long-term goals. Write them down. An unwritten goal is a wish. A class survey of an Ivy League university's alumni 20 years after their graduation found that the net worth of the 3% who left college with written goals exceeded the combined net worth of the remaining 97%. Writing your goals is no guaranteed path to wealth, but it is a way to improve your chances of success.

Based on your mission statement, write a set of short-term (less than one year) and long-term goals. Keep them where you will see them. Check off goals that are achieved. Revisit, modify, expand, and add new goals to your list. And make sure they are SMART: Specific, Measurable, Attainable, Relevant, and Timed.

Tactics

Tactics are all the things we do every day in our farming operations and sometimes they're based on tradition or "the way we've always done it." The feeding, fixing, fencing, and financing are all tactics. Tactics describe who, what, when, where, and how activities will take place to accomplish goals. Tactics should be goal-driven and mission-based. They are the things we do to reach our goals and fulfill our mission.

In the planning pyramid, tactics occupy the smallest section. This is not to suggest that they are unimportant. In fact, most of what farm operators do is tactical. And, the tactics have to be done right. Forage programs, nutrition, genetics, reproduction, herd health, marketing, facilities construction, and maintenance are all tactical activities that should be done correctly to ensure success. Most of our continuing education in the beef industry is focused on doing the right things and doing them right.

10 Traits of Top Managers

Top managers often share some common traits. While this is not an inclusive list, top managers are good at most of these items:

1. **Goal Driven.** They set and reach SMART goals.
2. **Data hounds.** They seek and use data to make decisions.
3. **Leaders.** They are people of character and integrity who others want to follow.
4. **Networked.** They have a strong network of colleagues and mentors.
5. **Dissatisfied.** They challenge status quo and seek better ways.
6. **Organized.** They can focus and prioritize.
7. **Risk-takers.** They view the future aggressively and take measured risks.
8. **Smart.** They know what they're doing and never stop learning.
9. **Hardworking.** "Smart" and "works hard" is a powerful combination.
10. **Recharge.** They know that physical and mental rejuvenation is necessary.

The key to making the planning pyramid work is to make sure all the elements are present. For every new tactic, we should ask these questions:

- How will I use this to help me reach one or more of my goals?
- How does this help me fulfill my mission?

If these questions cannot be answered effectively, perhaps we have chosen the wrong tactics. Or, even worse, we have not defined "why we're doing this"—the mission.

Applying these two questions can help build a successful and enjoyable farm business.

Summary

Management is the key to a successful operation. All five functions—planning, organizing, staffing, directing, and controlling—have to be present. Few managers are naturally gifted in these five areas. It is just as important to work at management as any other area of the operation. Management can be learned, and the rewards are significant.

Acknowledgment

Many of the concepts in this chapter were developed in the PRO-DAIRY program at Cornell University and the DAIRY-Excel program at The Ohio State University. The authors are indebted to colleagues in these two programs for sharing the material and for their help in launching a management education program in Kentucky. These materials have been adapted for a wide range of agricultural and small-business audiences in Kentucky and are delivered in management-focused workshop settings, including Master Cattleman and Cow College. The author would also like to acknowledge Dr. Jack McAllister for his effort in writing the original version of this chapter.

Record Keeping for Management Decisions

Darrh Bullock and Kenny Burdine

The area of beef cattle management that usually gets the least attention is the task of collecting, maintaining, and utilizing records. Records are important on many different levels and should serve as the centerpiece of any good management program. The level of record keeping practiced on a farm often defines the level of success that the operation can expect to achieve. Even the best operational managers can consider only a limited number of factors into each decision they make, whether short or long term. The ability to review historical information and use it in the decision-making process is the single factor that separates the premier managers from those who just "do a good job."

Most beef producers collect some level of records, and this function takes many forms. This can be as simple as a notebook or calendar in the pickup truck or using a pocket record book and transferring the data to a computer program. In any system, this first level of data collection is very important and is the key to having good information for decision making in the future. However, most producers never take the data they have collected and put it into a form that will help them make decisions that will impact the long-term viability of the business. For instance, most producers keep some form of calving records, but few carry through to calculating weaned calves per cow exposed, much less develop them into a system that can track the lifetime productivity of individual cows in the herd. Most producers keep up with out-of-pocket costs on an annual basis, but few can track how those costs impact the cost of production over time.

In this age of changing business structures throughout the beef industry and potential federal or marketing programs that may require some level of record keeping, it is important for managers to take the task of record keeping just as seriously as the day-to-day production tasks. Many producers are marketing cattle into systems that view cattle individually and establish market value on their individual merit. These types of systems continue to grow and impact the value of all cattle in the system. A potentially greater challenge/opportunity to cattle producers is the possibility for federally regulated compliance to marketing and disease-control programs. This will require some level of record keeping on the part of producers. In either scenario, a good record system puts the producer at a distinct advantage in the marketplace and protects that producer against any potential liability that may be created in such a system.

Record systems fall into two basic categories: production and financial. These two systems can operate independently of each other to a point, but to be truly meaningful and useful, they should work together as part of the overall farm management program. The differences in the two systems will be discussed and the information that could be included in each will be outlined.

No matter why the beef producer chooses to keep records, there is no question that a quality system of collecting, maintaining, and analyzing records can elevate the ability of any manager to a level much higher than those who operate without information. In the end, the decision is one of operating the farm and the beef enterprise as the businesses they are and protecting that business.

Record Systems

Production Records

Most beef producers maintain some form of production records. The production record system should be the system that maintains the information associated with the performance of the cattle and the production of the land. This is the easy piece to put together since we are dealing with numbers such as rolls of hay off a field or weight of a calf at weaning.

The real challenge in most production record systems is taking the information that is collected on a day-to-day basis and putting it into a form that can be utilized for decision making. Many tools are available to make this task simpler, such as pocket record books and the Integrated Resource Management (IRM) calendar. These tools are designed for use in the everyday setting for recording the events that take place and when and where they happen. For many producers, this is the end of record keeping, and this initial record-keeping tool is filed away and considered the long-term record. This scenario is all too common and is a basic form of record keeping, but how useful are those records? In the context of the business, they are not very useful because they give no means of comparing performance from year to year. Taking those initial records and putting them into some system that allows for their analysis is the step that often is missed. Many different systems exist for providing this service. Computer software is available for archiving and analyzing this information.

Moving to this level of performance record keeping will allow the beef producer not only to look at what is currently taking place within the cow herd but, more importantly, to look at how management changes (nutrition, health, breeding, etc.) impact the performance of the herd. Analysis of the long-term records can help to pinpoint weak areas in the management program and aid in identifying individual animals that fail to perform at profitable levels.

Financial Records

Many reasons exists for keeping financial records. When asked, many producers will often cite the filing of taxes as the primary reason they keep records. Other

producers might reply that records are required by the lenders they work with. However, a third reason to maintain good financial records is to have information that can be used for making management decisions. Each of these is an important function of the financial records system and, whatever system is used, it should most certainly satisfy the needs of each of these areas.

Similar to the challenge in the production records arena, most producers keep the records necessary to file taxes; however, once those taxes are filed, the records serve no purpose other than to support and defend the business in the event of questions relative to the tax return. In most operations, these basic tax records are the foundation—and are often adequate—to establish a system that will go far beyond filling out a tax form. They allow the producer to analyze the information and make use of it to improve the overall profitability of the business. Producers who know their unit costs of production and how their management decisions affect profitability are equipped to improve the performance of their business. Without the ability to look at these numbers objectively with all factors considered, it is impossible to make sound decisions that positively impact the direction of the beef enterprise as a business.

Suggestions for information required for basic and advanced systems are discussed later in this chapter, and sample data collection tools are available in Table 12-1.

Table 12-1. Suggested cow-calf (cc) and stocker/backgrounder (sb) production records.

Cow Information	
cc	Cow ID
cc	Birth Date (Approximate)
cc	Sire/Dam Record/Breed
cc	Vaccination Schedule and Dosage
cc	Health and Treatment
cc	Registration Information
cc	Date Entered and Exited Herd
Cow Performance	
cc	Sire Mated
cc	Pregnancy Test Results
cc	Calving Date
cc	Calf ID
cc	Calf Sex
cc	Calving Difficulty
cc	Culling Date
cc	Reason for Culling
Sire Information	
cc	Sire ID
cc	Birth Date
cc	Breed
cc	Registration Information
cc	Date Entered and Exited Herd
Sire Performance	
cc	Expected Progeny Differences (EPDs)
cc	Scrotal Circumference
Calf Information	
cc	Calf ID
cc	Birth Date
cc	Calf Sex
cc	Breed
cc	Vaccination Schedule and Dosage
cc	Health and Treatment
cc	Date Entered and Exited Herd
sb	Calf ID
sb	Calf Sex
sb	Breed
sb	Vaccination Schedule and Dosage
sb	Health and Treatment
sb	Date Entered and Exited Herd
Calf Performance	
cc	Birth Weight
cc	Weaning Date
cc	Weaning Weight
cc	Management Information (Creep/Twin/Etc.)
cc	Yearling Weight
cc	Slaughter Weight (if retained)
cc	Hot Carcass Weight (if retained)
cc	Ribeye Area (if retained)
cc	Backfat Thickness (if retained)
cc	% Kidney, Pelvic, Heart Fat (if retained)
sb	Weight at Purchase/Weaning—Date Purchased
sb	Weight at Sale—Date Sold
sb	Rate of Gain
Other Records and Documents	
cc	Beef Quality Assurance Program
cc	Replacement Program
cc	Animal Inventory
cc	Receiving Records
cc	Purchasing Records
cc	Sales Receipts
cc	Feed Bills
cc	Feeding Records
cc	Acreage Inventory
cc	Site Maps
cc	APHIS VS Forms
sb	Beef Quality Assurance Program
sb	Animal Inventory
sb	Receiving Records
sb	Purchasing Records
sb	Sales Receipts
sb	Feed Bills
sb	Feeding Records
sb	Acreage Inventory
sb	Site Maps
sb	APHIS Requirements
sb	Transfer of ID System
sb	VS Forms and Records

Getting Started

Identify Each Cow in the Herd

When assigning a visual ID to an animal in your herd, a producer should give some thought to an overall plan to avoid duplication of IDs. Also, most production record-keeping software will not recognize and allow the use of duplicate IDs within a herd.

A recommended on-farm ID system is the International Year/Letter Code Designations, as proposed by the Beef Improvement Federation (Table 12-2).

The International Year/Letter Designations for animal ID works by designating an internationally recognized letter for each year of birth. This option is very easy to use in conjunction with numbers. For example, E001 and E002 might be used to indicate the first and second calf born in the year 2017. When a heifer transfers to the cow herd, she can keep her ID, and new cows entering the herd can also be assigned an ID with their birth year letter code preceding their new individual ID.

Using this internationally accepted and recognized system promotes uniform identification throughout the industry and also puts a logical, uniform ID system in place on the farm. Using this proposed system of identification will reduce the possibility of duplicate identification and help the producer determine the age of an animal (down to the birth year) at one glance.

The type of identification depends on the individual producer. Any combination of identification that is readable from a short distance and permanent is acceptable. Some methods that work well are:

- Putting identical ear tags in each ear of the cow. If one is lost, replace it as soon as possible.
- An option for one tag is an EID (Electronic Identification).
- Putting an ear tag in one ear and the corresponding tattoo in the other.

- Freeze brands are permanent and a good option for dark hided cattle if done properly.

With these methods, when a cow inevitably loses a tag she can be identified. The identification of individual animals with a unique ID within a particular farm has several benefits such as the ability to trace each sire's and dam's progeny and evaluate their performance in terms of birth weight, birth weight ratio, adjusted 205-day weight ratio, EPDs, and the accuracy of EPDs.

Determine the Age of the Cows in the Herd

If records are not available, mouth the cows or estimate as close as you can (see Chapter 7, "Health and Management Techniques"). Weaning weights are adjusted based on the age of the cows; therefore, the more accurate your estimates are, the more accurate the adjusted weights will be.

Record the Breed of the Cows

If unknown, estimate the breed based on appearance. If she appears to be predominantly of one breed, list her as a cross of that breed (e.g., Angus cross, Charolais cross, etc.). If breed composition cannot be determined, list the cow as a crossbred. This record is not essential but can provide information on how particular breeds perform in your environment.

The use of breed codes is often recommended. A number of breed codes, as suggested by Beef Improvement Federation (BIF) guidelines, are listed in Table 12-3.

A total of four letters can be used to denote crossbred cows or calves. Always list the breed type of the sire first and breed type of the dam second. For example, if a calf had an Angus sire and his dam was a Simmental, list the calf as ANSM. Refer to the BIF guidelines for additional breed abbreviations.

Breeding Season

Take a Breeding Inventory

List all cows and heifers exposed through either natural service or artificial insemination (AI). Record all AI information, including identification and breed of the bull(s), tag number of the cow, and date of insemination. For natural service, record bull identification and breed, identification of the cows exposed to that bull, and the dates when the bulls were turned out and removed. This information is extremely important in determining the reproductive performance of the herd such as pregnancy percentage, pregnancy loss percentage, calving percentage, calf death loss percentage and weaning percentage (calving and weaning percentages are based on the number of females exposed to the bull), and calving distribution, as well as important production performance measures such as pounds weaned per exposed female.

Table 12-2. International year/letter code designations.[1]

P	2004	A	2013	K	2022
R	2005	B	2014	L	2023
S	2006	C	2015	M	2024
T	2007	D	2016	N	2025
U	2008	E	2017	P	2026
W	2009	F	2018	R	2027
X	2010	G	2019	S	2028
Y	2011	H	2020	T	2029
Z	2012	J	2021	U	2030

[1] The letters I, O, Q, and V are not used.

Pregnancy Test

Pregnancy information assists in identifying which females did not conceive so that culling options are available sooner. Also, this information helps determine when pregnancy problems are occurring. If a large number of females pregnant at the pregnancy test do not calve, losses during pregnancy due to disease or malnutrition likely are occurring and can be corrected.

Calving Season

Observing calving can provide useful information to help avoid calving losses. Information obtained at calving is essential to good record keeping and includes:

Calving date (required). The exact date may not be known if cattle are not checked daily, but estimates within three days are acceptable. Calving date is important to calculate weight per day of age where weaning weight and weaning date have been recorded.

Proper identification of calf and matching with dam (required). If calf identification is not done at birth, it must be done prior to weaning. If done at some time other than birth, an easy way to match calves with dams is to separate all the calves from the dams for a few hours and then turn them back together. Generally they will nurse immediately and can be matched easily in this manner.

Table 12-3. Breed codes.

AM	Amerifax
AN	Angus
AR	Red Angus
BB	Belgian Blue
BF	Beef Friesian
BG	Belted Galloway
BM	Beefmaster
BQ	Buelingo
CA	Chianina
CH	Charolais
CO	Continental
DS	South Devon
FV	Fleckvieh
GD	Golden Dakota
GV	Gelbvieh
HH	Horned Hereford
HP	Polled Hereford
LM	Limousin
MA	Maine-Anjou
MG	Murray Grey
MX	Crossbred
SA	Salers
SB	Brown Swiss
SG	Santa Gertrudis
SH	Scotch Highland
SM	Simmental
SP	Polled Shorthorn
SS	Scotch Shorthorn
SU	Braunvieh
TA	Tarentaise
TL	Texas Longhorn
WB	Welsh Black
XX	Crossbreeds

Calving ease score (very useful). The scoring system is:
1-Unassisted
2-Easy pull
3-Hard or mechanical pull
4-Caesarean section
5-Abnormal presentation

If unobserved but no problems apparent, score a 1.

Birth weight (useful). If unknown, BIF recommends using 70 pounds for females and 75 pounds for males, which is the value used by most computer programs to calculate 205 adjusted weight if birth weight is omitted. Where birth weight

and weaning weight for an individual animal have been recorded, the average daily gain for that calf can be calculated.

Weaning

Production records are of little value without weaning weights. If you do not own scales, many county organizations have them available. Check with your county Extension agent for more details. The following information can be collected at weaning:

- Individual weaning weight and date (essential).
- Weight and condition score of the cow (very useful).
- Sex of the calf (essential). If the calf is castrated prior to weaning, record as a steer; if castrated at weaning, record as a bull.
- Contemporary group code (essential). All calves raised under the same conditions receive the same contemporary group code. If a group of calves (or their dams) gets preferential treatment, it should get a different contemporary code. Producers who have spring- and fall-calving herds should use different contemporary group codes for each herd.

It is important that all animals born, whether dead or alive, are recorded and taken into consideration when the herd is being analyzed. Also, record any abortions and calf death losses, and make sure to record that information on the specific cow's lifetime history.

Yearling

If calves are to be kept through a year of age, whether to market at that time or be retained as replacements, additional records can be beneficial. The following information is needed:

- Individual yearling weight and date (essential). If weaned calves are purchased, a beginning and end weight and date will need to be recorded.
- Sex of calf (essential).
- Contemporary group code (essential). Same as with weaning weights.

Many producers might find other information useful. If so, this information should be recorded. Production goals of each operation are different, and records should reflect those goals.

Performance records are only beneficial if they are incorporated into management-making decisions. Records must be recorded accurately, analyzed, and interpreted. From the interpretation, informed decisions on selection and management practices can be made. These decisions become more economically sound if financial information is available and can be incorporated.

Feedyard and Carcass Performance

Gaining information on your cattle based on feedyard and carcass performance is often more difficult. Most Kentucky producers sell their calves at weaning or after backgrounding, and once sold, no more information is available to the producer. This situation is unfortunate because it does not allow commercial producers the opportunity to improve the post-weaning genetics of the herd, and if the herd already has high feedyard and carcass performance, the producer may be selling the calves for less than their true value. Without obtaining feedyard and carcass performance information, it is impossible to determine the value of future calf crops. Several options are available for Kentucky beef producers to obtain feedyard and carcass information; county-based feedout programs and the carcass data collection service by the Kentucky Department of Agriculture. Several Kentucky Cattlemen have been sending cattle to the Tri-County Steer Carcass Futurity Cooperative (http://www.tcscf.com/index.html) with great success on collecting feedlot and carcass data. Producers are using the information to change the genetics of their herds to capture added value. Another service that is available is the Kentucky Department of Agriculture's Beef Carcass Grading service. This service is available to beef producers to assess the USDA Quality and Yield grades of their cattle that are fed out at home.

Record-keeping Systems

A computer is not required to maintain accurate farm records, but is advised for more complex systems. Producers need to choose a record-keeping method that works best for them, whether it is a notebook on the dash of the truck, a computerized spreadsheet, or software program. A list of record-keeping programs can be found below. Keep in mind that these are not the only programs available for record keeping. Breed associations and other groups may have other programs that will work better in your situation. A very useful source of information on various computer record keeping options is an Oklahoma State University publication entitled *Cow-Calf Production Record Software* is available at the following link: http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1926/CR-3279web15.pdf.

Financial Record-keeping Systems

Specialists with the University of Kentucky Farm Business Management program (KFBM) are excellent resources for financial recording keeping expertise for the beef operation. Information about this program is available at http://www.uky.edu/Ag/KFBM/. Many programs for financial record keeping (Quicken®, Quickbooks®, and Kentucky Farm Record Book, for example) are primarily whole-farm based and will not provide the producer with an in-depth cow-calf or backgrounding financial analysis. Quicken® and Quickbooks® are both computer-based, and the Kentucky Farm Record Book is paper-based.

Quicken® and **Quickbooks®** are computerized record-keeping programs that allow producers to categorize their income and expenses and run reports using that information. They are also compatible with checking and credit card accounts and easily allow for producers to separate their farm expenses by enterprise using categories and sub-categories. Categories and subcategories can allow users to complete beef enterprise or herd analysis as long as the expenses and incomes are allocated and categorized appropriately. The University of Kentucky Department of Agricultural Economics Web page has a list of farm categories that producers can access. Search for "Quicken Categories" on the Ag Economics web page.

Kentucky Farm Record Book (Brown Book) is a hand record-keeping system for keeping farm cash costs. The book allows the producer to record cash income and expenses, sale and purchase of capital items, labor expenses, and withholding

transactions. Once completed, this information will serve to help complete the producer's Schedule F tax form.

Beef Enterprise Budgets can be found at http://agecon.ca.uky.edu/files/extbudgetbeef200829.xls. Budgets for cow/calf enterprises, replacement heifers, steer backgrounding, and summer grazing can be downloaded and utilized. These spreadsheets can be customized to a cattleman's specific needs.

Production and Financial Record-keeping Systems

Microsoft® Excel Spreadsheet—Producers can use Excel or other spreadsheet software to set up a worksheet that will allow them to keep all their records. A producer can insert formulas into the columns to create summaries and calculate information such as average daily gain or days to weaning, total income or expenses, and much more. However, spreadsheets will not run specific reports like other programs.

Table 12-4 shows suggested financial records that need to be kept to determine the cost of production of a herd. A typical cow-calf operation consists of several different enterprises so it is important to keep records on each one.

The examples listed in this table are not inclusive of all records and documents that may be needed to comply with all marketing and disease-control programs.

Table 12-4. Suggested financial records.

Cow-Calf
Number of Females Exposed to Bulls
Calving Distribution
Calves Born Alive
Calves Born Dead
Calves Lost Nursing
Total Calves Weaned
Average Actual Weaning Weights
Average Calf Age at Weaning
Average Weaning Weight Per Cow Exposed
Replacement Rate and Average Weight
Breeding Cattle Deaths
Dominant Breed in Herd
Dominant Pasture Utilization
Opening and Closing Inventories
Current Market Value of All Cattle
Raised Hay Inventory
Equipment and Building Depreciation
Short and Intermediate Loan Summary
Grazing and Hay Land Acres
Rental Value of Grazing and Hay Land
Human Resource Information (Hired and Family)
Allocated Cash Costs
Feed Used by Herd (Raised and Purchased)
Cattle Sales
Cattle Purchases
Grazing Resources (Pasture, Cornstalk, Stockpile)
Hay Production and Market Value
Supplement Used by Herd

Stocker/Backgrounder
Dominant Breed in Herd
Dominant Pasture Utilization
Opening and Closing Inventories
Current Market Value of All Cattle
Cattle Sales
Cattle Purchases
Deaths
Raised Hay Inventory
Equipment and Building Depreciation
Short and Intermediate Loan Summary
Grazing and Hay Land Acres
Rental Value of Grazing and Hay Land
Rental Value of Grazing and Hay Land
Human Resource Information (Hired and Family)
Allocated Cash Costs
Grazing Resources (Pasture, Cornstalk, Stockpile)
Hay Production and Market Value
Feed Used by Herd (Raised and Purchased)

Mention of specific commercial products is for educational purposes only and not considered an endorsement of the product. Product names are mentioned to report factually on available data and to provide specific information.

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