CATTLE
management manual

A reference for agency staff, department employees, loan officers, and others with a need to consult cattle management information

Douglas Reynolds, James Waggoner, and Michael Smith

November 2000
MP-97

Authors:
Douglas A. Reynolds, University of Wyoming Cooperative Extension Service Chair, Carbon County, Rawlins, Wyoming

James Waggoner, Range and Livestock Specialist, Department of Renewable Resources, University of Wyoming College of Agriculture

Michael Smith, Range Specialist, Department of Renewable Resources, University of Wyoming College of Agriculture

Editor: Diana Marie Hill-Chavez, College of Agriculture, Office of Communications and Technology

Graphic Artist: Tana Stith, College of Agriculture, Office of Communications and Technology

Typing: Charlene Abbott, University of Wyoming Cooperative Extension Service, Carbon County, Rawlins, Wyoming

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Glen Whipple, Director, Cooperative Extension Service, University of Wyoming, Laramie, Wyoming 82071.

Cooperative Extension Service
UNIVERSITY OF WYOMING
College of Agriculture

Table of Contents

Chapter 1

Cattle Behavior and Grazing

Information about cattle instincts and associated behavior is a valuable tool that helps producers understand why cattle behave or respond as they do.

Although cattle have been domesticated for a very long time, they are dictated by the herding instinct, especially if they perceive a dangerous situation. Cattle depend heavily upon sight, and they have a nearly 360-degree panoramic view. This vision scope allows them to see a predator without turning their heads. However, they have limited effective depth perception beyond the frontal view, which explains why they may balk when being driven or worked in a handling facility (see Figure 1).

Cattle are sensitive to light and dark contrasts such as shadows. Slated fences and vertical bars in a working facility cast shadows that may interfere with cattle movement. Research suggests cattle are not color blind; however, painting handling facilities a bright yellow results in fewer injuries because cattle can better see a gate or fence. No one can explain why cattle that have never been exposed to an actual cattle guard will refuse to cross one that is painted on the road.

Humans rely heavily on vision to interpret their environment, and we like to believe other animals also have these capabilities. Cattle, however, use other senses such as hearing, taste, smell, and orientation. These highly developed senses are referred to as "cow sense."

A bubble-shaped area called the flight zone surrounds a cow. When another animal, human, or object penetrates this zone, the cow either fights, runs, or submits, depending on whether the animal or object entering this zone is perceived as dominant.

Figure 1. The shaded areas represent the cow's blind spot.

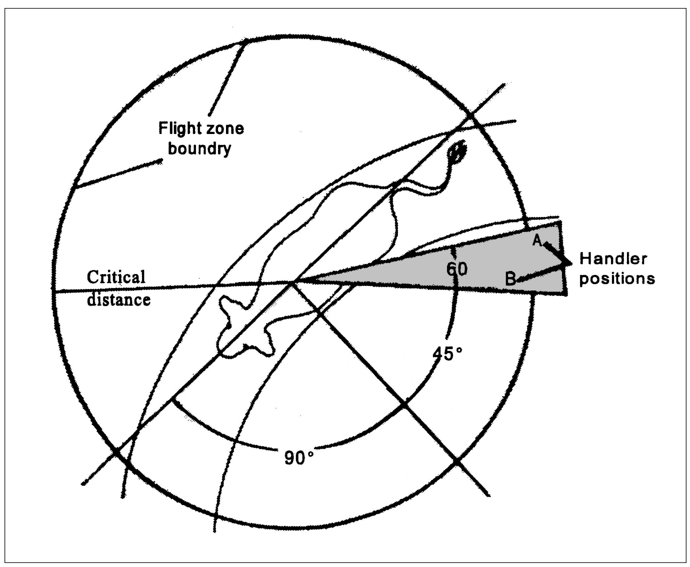


Figure 2. The triangle area shows where handlers should stand when moving an animal. To make the cow move forward, the handler should move into Position B, which is just inside the boundary of the flight zone. The handler should retreat to Position A if he wants the animal to stop. The solid curved lines indicate the location of the curved single-file chute.

The flight zone's radius ranges from 5 feet in dairy cattle to 300 feet in range cattle, and it will change according to conditions. Cows will not tolerate flight zone penetration at 300 feet on open range, but when they are corralled or being fed during the winter, the zone ranges from 20 to 30 feet. When working or moving cattle, the handler should stay on the flight zone's edge (see Figure 2).

Cattle herds have a pecking or bump order, meaning the herd consists of a wide range of dominant and submissive animals. Cattle have a strong instinct to follow a leader; however, herd leaders are not necessarily the dominant animals. Behavior between dominant and submissive animals is complicated. For example, X is dominant over Y, Y is dominant over A, or X and Y together dominate C. However, X or Y cannot dominate over C alone, which means that C is dominant over X and Y. Both dominant and submissive animals can cause disturbances–especially when strange cattle are introduced into the herd–because the bumping order has to be worked out again. Also, a cow in heat changes the bumping order, creating a disturbance. It may be in the best interest of the herd to cull both extremely dominant and submissive animals, because their behavior is probably genetic.

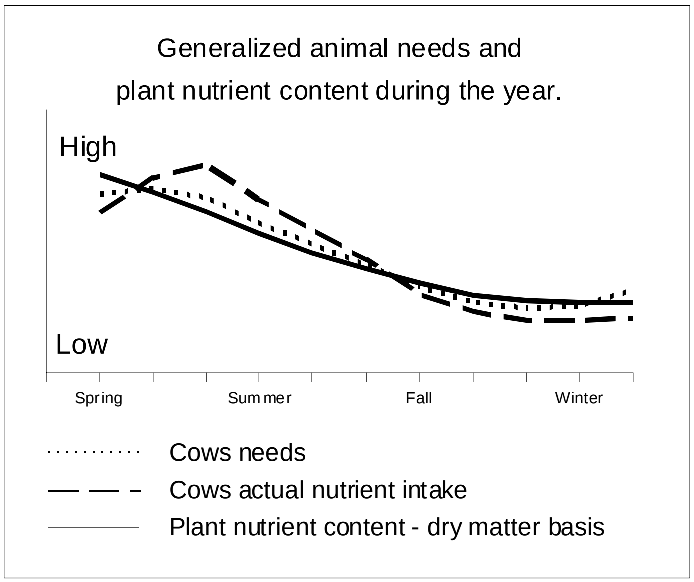


Figure 3.

Cattle must lower their heads to determine distances.

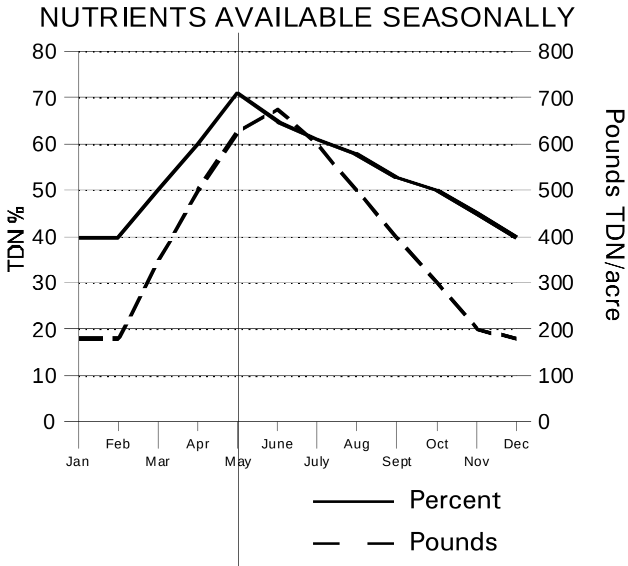
Habitat and Forage Selection

Cattle select a habitat or forage where optimal grazing is available. Getting enough nutrients to balance amounts of expended energy is important (see Figure 3).

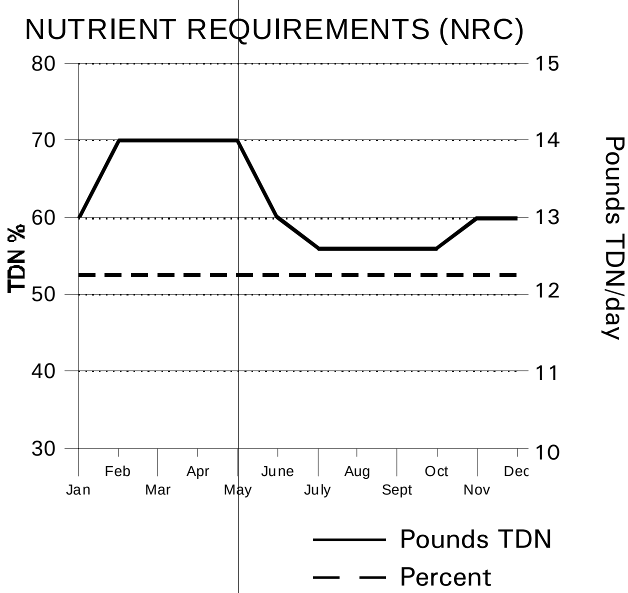
Habitat and forage selection will be both extensive and microscaled within larger areas. For example, when choosing which plant to bite, cattle will select mid-sized bunches over small- or large-sized bunches. This method allows them to maximize intake and reduce energy expended.

The following three graphs show:

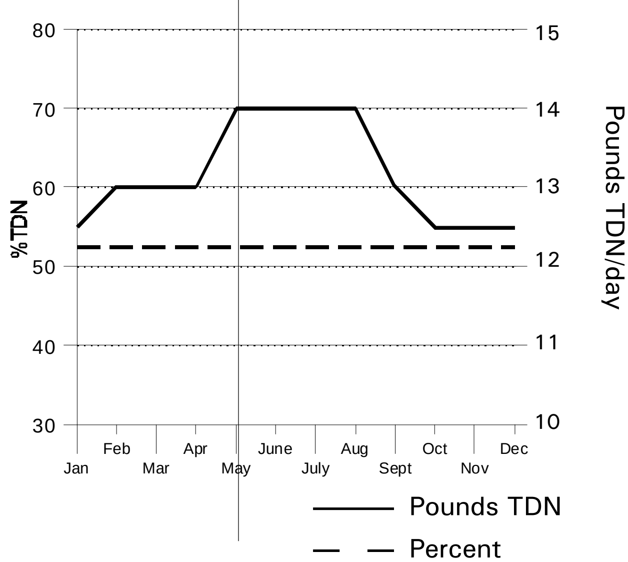
- How production and percent TDN (energy) of native range relate to each other
- The TDN requirements of a February calving cow
- The TDN requirements of a May calving cow



Graph 1.
Assume 1,000 pounds per acre annual growth peak in late spring.



Graph 2.
Diet of a 1,000-pound cow calving in late February.



Graph 3.
Diet of a 1,000-pound cow calving in late May.

Cattle wrap their tongues around forage and rip the plant parts. When grass is very short, cattle may change their method to a biting action, but because they have incisors on the bottom jaw only, the amount of forage that can be taken is limited. In either case, cattle chew little and swallow rapidly. The herd usually orients itself in the same direction while grazing but not necessarily while resting.

When grazing on smooth areas with at least moderate amounts of forage, cattle move forward swinging their heads in a 60 to 90-degree arc, and an area approximately twice their body width is cleared. Rough pastures are grazed differently because cattle may stand to graze, but more body movement is required between grazing areas. Two major grazing periods are predawn and sundown; however, if cattle are moved to a new area, where fresh feed is available, they will change their feeding patterns. Dormant winter forage is used best and lasts longer if cattle are rotated rapidly through several pastures more than once. This rapid rotation allows the best forage to be taken the first time through; the next best forage, in terms of quality, is consumed during the second grazing period. This method stabilizes the nutrient intake over a longer period than would be possible if cattle were allowed to graze a pasture until they depleted the forage.

When cattle are moved to fresh feed, they will ignore the major grazing periods of predawn and sundown.

The selectivity for available forage can normally be assigned to three different approaches during a grazing period:

- Initial–Intermittent and low selectivity
- Primary–Steady with increasing selectivity
- Final–Intermittent and high selectivity

Cattle selectivity is directed by both natural instinct and learned behavior, providing producers opportunities for manipulation. Cattle choose forage based on protein, fiber, and moisture content.

Cattle evolved to fill a particular niche in the environment and, consequently, their body size and shape, stomach type, mouth size and dentition, and other characteristics heavily dictate habitat selection. Cattle generally seek adequate forage quantity as opposed to spending energy in search of more scarce, high-quality forage.

Cattle select preferred habitats according to plant quality and quantity, topography, elevation, climatic factors, and human manipulation. Selecting a preferred habitat based on quality and quantity may be reduced when other factors are in effect.

Energy requirements are proportional to body weight, within size ranges for game animals and livestock. A useful method for comparing big game and livestock is an "Animal Unit" (AU) basis, in which AU = .001 x body weight.

Table 1. Animal unit values (AU) for different kinds and classes of livestock and wildlife. The standard for this guide is based on forage intake of a spring calving cow (1,000 pound average milking ability) and her calf less than four months old. (These AUs do not apply for billing on federal grazing permits.)

Kind/Class of Animal	AU	Number of Animals to = 1 AU
Cow (1,000 pound and calf) spring calving above average milking ability, first 3 to 4 months postpartum	1.00	1.0
Cow (1,000 pound) nonlactating	0.90	1.1
Calf (spring calving, 3 to 4 months postpartum to weaning)	0.30	3.3
Replacement heifers (18 to 24 months)	1.00	1.0
Yearling cattle (long 12 to 17 months)	0.75	1.4
Yearling cattle (short 7 to 12 months)	0.50	2.0
Young bulls (12 to 24 months)	1.20	0.8
Bulls (24 to 60 months)	1.50	0.6
Yearling horses	0.75	1.3
Two-year-old horses	1.00	1.0
Mature horses	1.25	0.8
Mature lactating ewe (150 pound) and lamb (less than 2 months old)	0.20	5.0
Mature nonlactating ewe (150 pound)	0.18	5.5
Lamb (2 months to weaning)	0.06	16.7
Lamb (weaned to yearling)	0.12	8.3
Lamb (yearling)	0.15	6.6
Ram	0.25	4.0
Goat (mature)	0.15	6.6
Kid (yearling)	0.10	10.0
White-tailed deer	0.15	6.6
Mule deer	0.20	5.0
Antelope	0.20	5.0
Bison (cow)	0.90	1.1
Bison (bull)	1.50	0.66
Elk	0.60	1.7
Moose	1.00	1.0
Bighorn	0.20	5.0
Mountain goat	0.15	6.6
Blacktailed jackrabbit	0.016	62.0
Whitetailed jackrabbit	0.02	48.0
Columbian ground squirrel	0.003	385.0
Prairie dogs	0.004	256.0

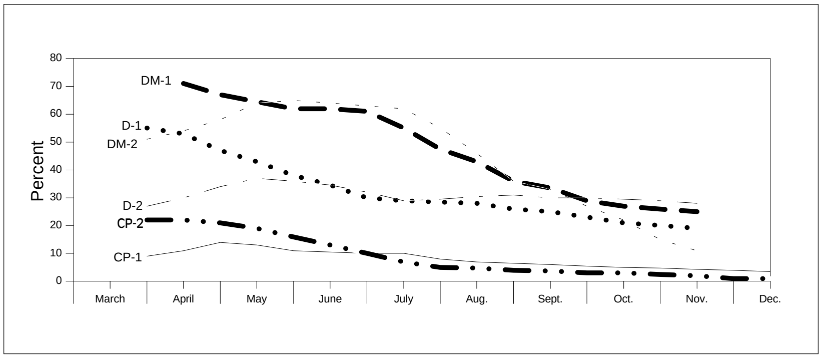


Figure 4. Seasonal trends in nutrient concentrations of crude protein (CP), apparent digestibility (D), and daily dry matter intake (D1, D2) of bluebunch wheatgrass (1) and Idaho fescue (2) in south-central Oregon.

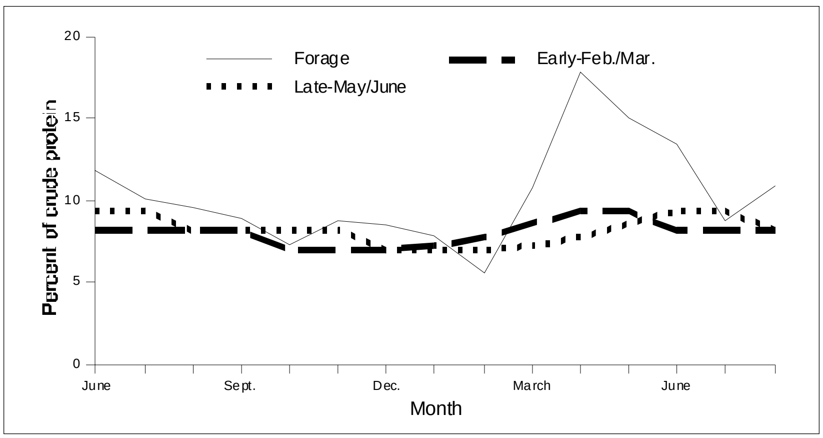


Figure 5. Average percent of crude protein present in forage and needed in diets of early and late calving cows grazing shortgrass native range near Cheyenne, Wyoming. Forage energy levels and requirements follow similar profiles.

A sample of this native forage indicates the combined quality of the entire plant. Cattle carefully select the parts they actually graze.

Factors Affecting Selectivity

Understanding selectivity for plant type and habitat assists producers when developing range management strategies, which include setting carrying capacities, determining appropriate monitoring methods, predicting plant and animal responses to management, and locating range improvements. Factors that limit habitat selection, such as natural barriers, slopes, and distance to water or fencing, can reduce quality and quantity, resulting in decreased animal performance and perhaps less than desirable forage utilization levels. Eventually, carrying capacity will be reduced. Major factors that influence selectivity are:

- Quantity, quality, and forage availability
- Plant maturity

Other factors, however, do affect habitat selection and become important in local situations.

Topography

The effects of slope lengths and steepness are well recognized as limitations to grazing, but topography also affects where water and accompanying attractive vegetation are located.

Topography also dictates where:

- Winter snow accumulates or blows away with corresponding dormant season habitat use
- Snow melts in spring, providing temporary water sources and high moisture vegetation (animals use areas farther from permanent water)
- Certain exposures green up earlier in the spring because of wind and solar energy (these areas act like magnets for all grazing animals)

Water

Whether or not cattle graze away from water is influenced by distance and topography. However, breed and learned behavior also play a role in grazing habits. When snow melts and succulent spring feed is available, the grazing distance may increase, or cattle will decrease time spent at the water source. Certain cattle are conditioned to use snow as a water source–as horses and sheep commonly do. Desert cattle may water at intervals and travel longer distances to preferred habitats.

Cover

Like all animals, cattle naturally seek areas that provide a thermal-neutral or comfortable environment such as shade in the summer and protection from the wind during cold weather. These locations change seasonally, daily, and hourly as the weather, temperature, and wind direction changes.

Insects

Cattle and other large herbivores go to extremes to avoid flies, mosquitos, and other annoying insects. Often, they search for windy locations. Cattle may bunch to avoid mosquitoes and horn flies. When heel flies pursue a herd, cattle may move into habitats or bordering allotments they would not normally use.

Animal Class and Social Behavior

Steers or spayed heifers normally distribute themselves more effectively than cows traveling with young calves. Also, these yearlings are more likely to use a habitat not frequented by cows and calves.

When cattle are familiar with an area, they do not have to spend much time locating preferred areas. They have expectations for certain locations and can remember recently depleted places. Inexperienced cattle may scatter themselves more extensively and may not perform as well as those who know the landscape. Mixing new cattle with those already moved to preferred areas facilitates the learned grazing behavior.

Grazing Systems and Range Improvements

A rotation system is typically accompanied by fencing and water development, both of which may play a role in changing habitat selection and past distribution patterns. Meanwhile, animal performance decreases while cattle bunch against a new fence or become adjusted to a new water source. Professional range managers often impose these changes for vegetation improvement without much thought about how these actions will affect the livestock.

Prescribed burns are one example of vegetative manipulation. Depending upon how much manpower is required, which fire control measures are employed, and whether it is spring or fall, prescribed burns may cost between $2.40 to $4 per acre.

Vegetative management also can be detrimental to range health. The vegetation in this national park changed from tall grasses to Russian thistle or tumbleweeds when cattle grazing was removed.

Increasing herd density by cross fencing may not change forage or habitat preferences within the pasture, but it will force cattle to use less-preferred areas. Producers may use this method as a management strategy to make use of underused grazing areas. Nevertheless, close attention to time control is necessary. Planned grazing programs (holistic management) go one step further than time control by imposing planned utilization levels.

Vegetative Manipulation

Altering a plant community type or removing decadent plant material may affect habitat selection by cattle, sheep, and wildlife. These changes include brush control, reseeding, planned grazing by herbivores and horses, and other practices that improve forage availability, leaf-to-stem ratio, or total production (biomass).

Chapter 2

Cattle and Riparian Management

Riparian zones and associated stream channels are related to erosion and deposition cycles. A stream's basic function is to remove water and sediment from its drainage basin. As sediment is subsequently deposited, a process of bank building occurs, changing plant communities. Different bank building stages, from bare banks to overhanging banks (late seral stage), may occur in any particular reach of stream. The BLM manual, *Riparian Area Management Process for Assessing Proper Functioning Condition,* indicates that the late seral conditions where bank building has occurred are the ideal definition of a properly functioning stream, but the publication does not address the erosive processes that have enabled this stage to occur. Figure 1 shows five stages in channel evolution, any one of which could be defined as properly functioning at a specific time in the cyclic process.

In smaller and mature stream channels, the annual flow does not include several tributaries, so overhanging banks may form. In larger streams, where the majority of flow is contributed by tributaries, the width and depth of the channels will adjust to high flow conditions. In situations like these, well-vegetated banks round off into the larger channels where low flow will become isolated between banks. Overhanging banks do not usually develop, except on the outside of bends.

Stubble Height and Sediment Deposition

Streambank vegetation increases channel roughness, which dissipates stream energy and causes sediment deposition. Streambank vegetation also protects banks by slowing the erosion process. The management objective is to determine how much stubble height is needed to effectively trap sediment while maintaining plant health. Tall grass causes flow resistance to decrease as it lays over, and flow velocity and channel depth increase. The vegetation effectively acts like a shingle that allows sediment to pass over.

Research conducted in Wyoming during a four-year period did not show any difference in the amount of

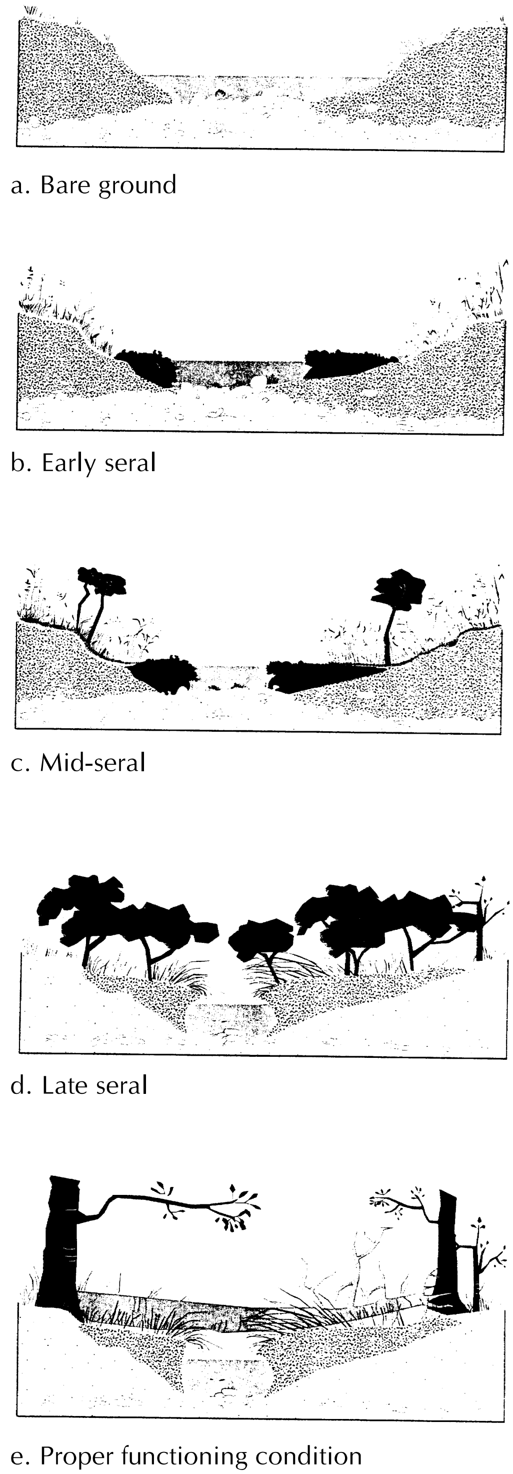


Figure 1. Channel evolution.

sediment deposited when vegetation was clipped to 1 inch, 3 inches, 6 inches, or left unclipped. However, sediment deposits decreased at levels above stream flow. Annual deposits varied from less than .5 inch to 2.4 inches.

United States Forest Service research showed that flexible vegetation, such as Kentucky bluegrass, trapped more sediment at ½-inch than at 3- or 8-inch heights. Rigid vegetation, such as grazed coyote willow, trapped less sediment than bluegrass; although less sediment was lost by subsequent flushing, flexible vegetation still resulted in a higher net gain.

Differences in the heights or rigidity of vegetation may be insignificant when compared with channel characteristics, flow level, and the sediment source. Under certain conditions, deposits will build on bare point bars. Succeeding vegetation stabilizes the deposit and allows channels to move through the sequence. Stored sediment eventually is removed by channel meandering and slope adjustment when it exceeds the system's capacity to hold it in place. Headcuts are a form of slope adjustment related to changes in water elevation due to blown out beaver dams or lower water in an area where a tributary unloads.

Plant Composition and Soil Water

Managers recognize and judge riparian area conditions partly because of plant species composition. Plant composition will change with channel succession, as shown in Figure 2. The late seral composition of

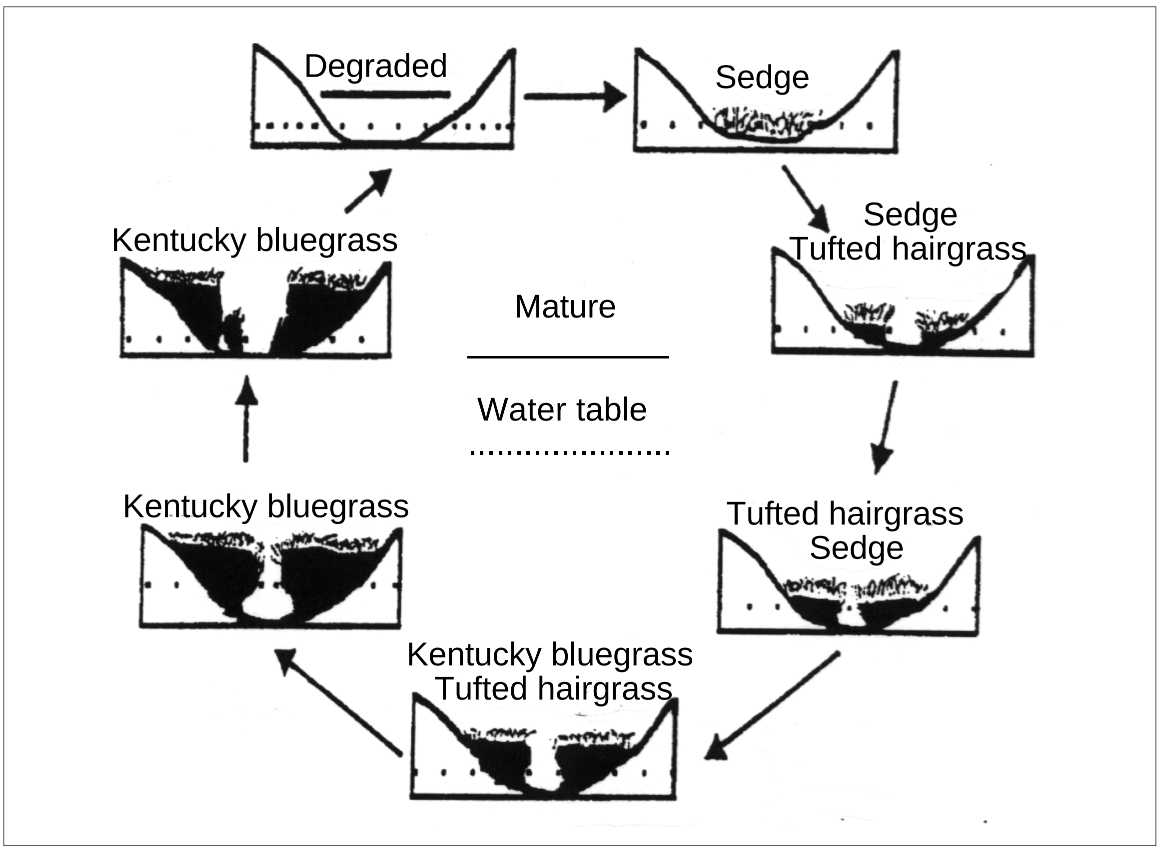


Figure 2. Plant and channel succession. A hypothetical sequence illustrating channel and plant succession, assuming erosion is a cyclic process.

upland plants may surprise managers, but observations confirm that as the soil surface moves farther away from the water table due to bank building, water-loving species are replaced by those more resistant to drier conditions.

Plant species will be affected both by soils' drainage characteristics and their relative position to channels or to the water table. Plant stubble height standards may have to be altered as plant composition changes due to channel succession or alteration. Figure 3 shows a hypothetical relationship between a channel configuration and certain plant species.

Plants respond differently to a declining water table, depending on whether it is seasonal or long-term. Kentucky bluegrass is more aggressive than Nebraska sedge or tufted hairgrass about growing roots to keep up with a declining water table. Figure 4 shows the relative root depths and weights at a point of maximum water table depth where decline was at 4 centimeters per day (all plants died at the maximum root depth).

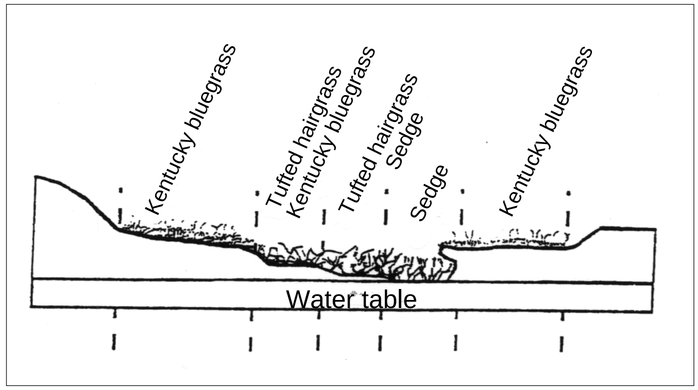


Figure 3. Hypothetical relationship between channel configuration and plant succession.

Beaver activity can dramatically change the water table and the vegetation associated with moisture availability. These interactions should be monitored and recorded.

Figure 4.

	Maximum root depth (cm)	**Total root length (cm)**	**Weight (grams)**
Kentucky bluegrass	31	330	147
Tufted hairgrass	20	183	70
Nebraska sedge	11	189	118

Note: Root weights shown are those in the top 8 inches of soil. They reduce rapidly after this depth.

Figure 5. Muddy Creek study area: grazed July 18 and19, 1996 (75 head of steers).

Cell no.	P.P. no.	Species	Grazed height			Recovery	Habitat
			July 18-19	August 19	October 2		
1	1	Nebraska sedge	4.5 in	4.5 in	5.0 in		Wet channel
1	2	Beaked sedge	12.5 in	13.0 in	13.0 in		Wet channel
1	3	Bluegrass and sedge	8.5 in	9.0 in	10.0 in		Moist
1	4	Beaked sedge	10.75 in	13.0 in	10.5 in		Moist
1	5	Beaked/Nebraska sedge	4.0 in	8.75 in	6.5 in		Wet (in water)
1	6	Nebraska sedge	6.5 in	6.0 in	6.5 in		Moist
1	7	Nebraska sedge	5.0 in	4.0 in	5.5 in		Dry
		±	7.4 in	7.8 in	8.1 in	.7 in	
1	Cage	Nebraska sedge	24 in	24 in	26 in		

Summary:
1. Average grazed height = 7.4 inches
2. Time in cell = 23 hours
3. Recovery noted is most likely due to measuring errors

Soil Water Summary

Soil water supply limits plant growth, especially in late summer, even in riparian zones. Pay attention to grazing timing because compensatory growth may not occur at certain elevations, slopes, and aspects. Regrowth in areas of lush growth where grazing has been limited or stubble height standards are over 5 inches is hampered by too little sun, which is vital for photosynthesis. See Figure 5 for a summary of regrowth at the Muddy Creek study area.

Figure 6 shows relative periods of growth for upland and riparian zones. Due to the extended period of rapid growth found in riparian areas, plants should have more time to recover from grazing. However, cattle often graze near the end of the rapid growth period (July 18 in Figure 5). Although water is available, the plants are maturing, and nutrients are being funneled into reserves. Note: Root reserves are a myth, carbohydrate reserves are stored primarily in plant crowns.

Stubble Height and Plant Health

When rangeland managers use residual stubble height as a grazing management tool, a logical question is how much stubble height is required to maintain healthy forage plants? Unfortunately, the answer to this question is complex, and reliable research that specifically addresses this question is virtually nonexistent. The capability of plants to withstand and

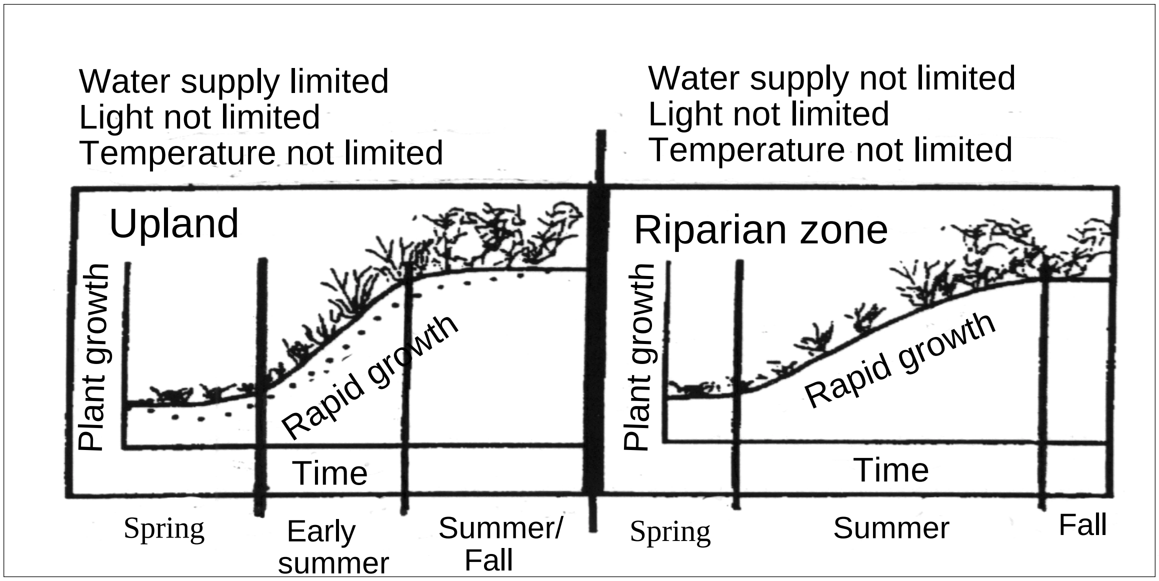


Figure 6. Upland and riparian cool season grasses growing curve.

recover from defoliation (grazing) is highly variable and depends upon available water, nutrients, and sunlight. Plant response to defoliation also fluctuates among individual species. Despite the variability in plant responses to grazing due to growing conditions or species adaptations, it is generally accepted that the most critical factor in a plant's recovery from defoliation is the presence of adequate photosynthetic material (green plant material) after grazing. Although plants may use stored carbohydrates to initiate regrowth after defoliation, regrowth largely depends upon photosynthetic energy produced from remaining green plant material. Consequently, the objective of grazing management during the growing season is to leave adequate green leaf material after grazing to make regrowth possible and allow forage plants to recover.

We are now back to our original inquiry–how much residual stubble is adequate? Recently developed prescriptions for grazing management often suggest having 2, 4, or 6 inches of stubble height. Although these guidelines may provide for regrowth and recovery after grazing, plant health was not the primary consideration in developing these prescriptions. In fact, most stubble height standards were developed to optimize sediment entrapment or reduce streambank damage; little consideration to the physiological requirements of plants was given. However, experience indicates that 2 to 4 inches of residual plant material should provide adequate photo-

No seasonal plant recovery was measured at this location grazed in mid-July.

synthetic material, so plants can regrow. It is imperative to recognize that stubble height (and utilization) is simply a short-term monitoring/management tool, and that no prescriptions or guidelines will work with every plant community in all situations. The overall goal of grazing management is to maintain or progress toward management objectives. Stubble height measurements offer no evidence of performance in reaching this goal. The best recommendations for appropriate stubble height are to establish realistic plant community objectives and to let animals graze at a stubble height that promotes the attainment or maintenance of the plant community that meets these objectives.

Figure 7 illustrates the difference between species when above-ground weight is used as the criteria. The difference exists due to growth form and whether the plant mass is concentrated near the ground, as in bluegrass and tufted hairgrass, or more evenly distributed from the crown to greatest height in sedge. No research indicates that 50 percent of plant stubble weight is not sufficient to maintain plant health. Studies conducted in Wyoming maintained riparian plants at 1, 3, and 6 inches and unclipped over four growing seasons. Above-ground production was used as the indicator of plant health. Below-ground biomass also was measured, and results showed no difference in weight due to stubble height. Apparently, no root damage occurred.

No herbage yield difference was found between the 1 inch and unclipped treatments, but both produced more than the 3- or 6-inch treatments. These studies have low reliability, as the removal was mechanical and did not include either positive or negative impacts due to hoof imprinting or animal disturbances. Also, the effect on individual species was not observed. Even if a 1-inch stubble height may appeal to a plant's production efforts, it still may not be adequate for public acceptance.

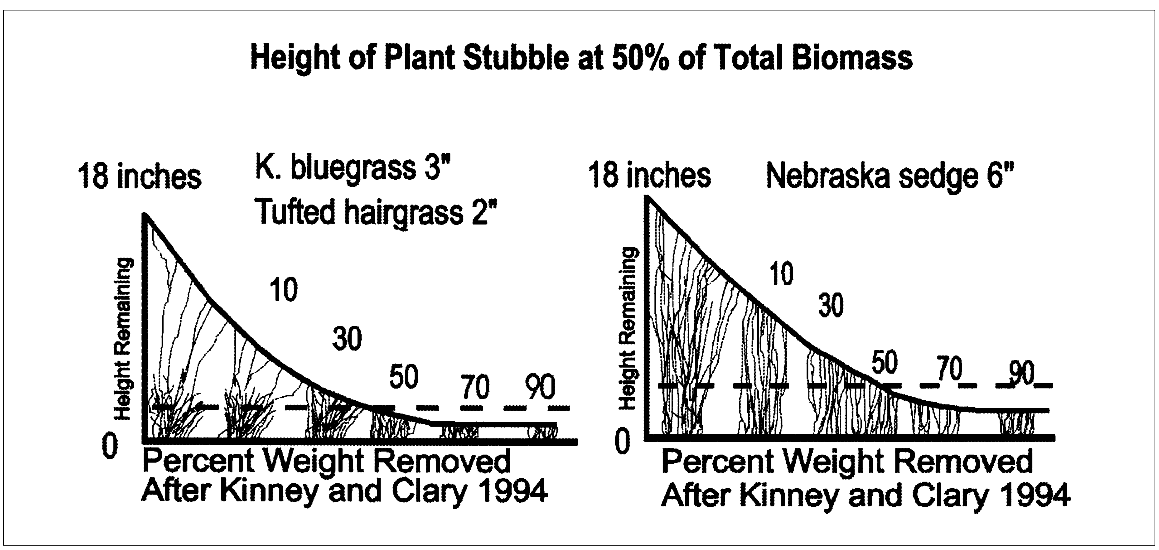


Figure 7. Illustrated height of remaining vegetation when 50 percent of the above-ground total weight is removed for three 18-inch high, grass-like cool-season plants.

Stubble Height and Bank Stability

Research indicates that maintaining shorter stubble heights may actually increase sediment deposits and above-ground biomass production without damaging the health of grass-like plants in riparian locations. However, as livestock graze to short stubble heights, hoof imprinting on soft, wet soils may damage channel banks and force animals to eat other desirable plants such as willows.

Two distinct areas along channels are the sections directly adjacent to water (the greenline), where vegetation may be composed of tall sedges and rushes, and the transition zone to upland, where bluegrass and hairgrass may dominate. By monitoring the greenline vegetation stubble heights, it should be possible to predict when bank damage will occur. However, as channels mature with bank building processes, it becomes more difficult to define these two areas, and monitoring stubble heights may need to be done differently. Small, mature headwater streams with overhanging banks are likely to be impacted by animals, stream dynamics, and ice. Under mature conditions, banks usually are built up with softer soils, while vegetation may provide minimal protection as root masses are confined primarily to the top 6 inches. Bank conditions vary seasonally, and they also are affected by drought or above-normal precipitation. Therefore, stubble height standards need to be adjusted to coincide with a variety of soil conditions. Research conducted by the United States Forest Service provides some guidelines for monitoring that can help prevent damage to wet soils and channel banks.

- Pay attention to the stubble height of the most palatable species as it approaches 3 inches.
- Greenline vegetation is often the least desirable and the last used.
- When the stubble height moves from less than 1 to 3 inches, depending upon the grass species, be prepared to move cattle.
- Keep track of the most palatable grass species' greenness, and when the grass dries, expect animals to seek greener vegetation.

Note: For additional information, refer to: *Stubble Height and Function of Riparian Communities* by Quentin D. Skinner, University of Wyoming.

"Greenline" vegetation, or vegetation next to the channel, may be the last used. Monitor its use and be ready to move cattle before bank damage occurs.

Chapter 3

Cattle Nutrition

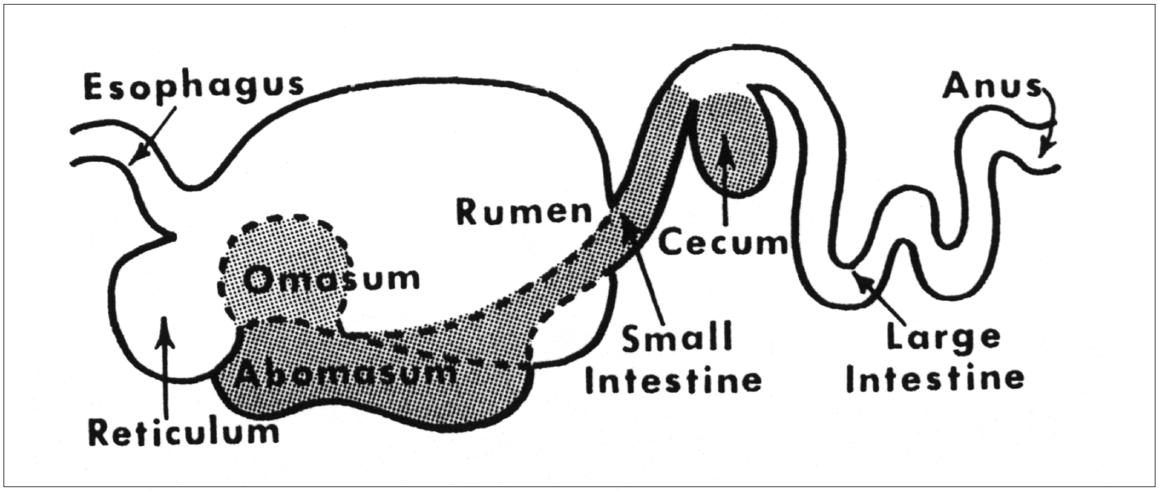


Figure 1. Ruminant animal digestive system.

The Ruminant Digestive Tract

The diagram above depicts a ruminant animal's digestive system. Although ruminant animals are often described as having four separate stomachs, they actually have one stomach comprising four separate compartments. The primary difference between the digestive tracts of nonruminant animals (pigs, dogs, and others) and digestive systems found in ruminants (cattle, sheep, elk, and deer) is that ruminant parts from the mouth to anus (tube) have become specialized for digesting high-fiber diets. This specialization or modification of digestive systems separates animal species.

Rumen and Reticulum

No actual division between the rumen and reticulum exists. An average 1,000-pound range cow can hold 45 to 65 gallons of digesting material (250 pounds of feed, saliva, and water) in the rumen and reticulum.

Ruminants have no upper incisors, so when grazing, they pin the forage between their lower incisors and hard palates, located on the front part of their upper jaws, where upper incisors are found in other animals.

Ruminants tear or rip forage, which explains why grass and forage plants may be pulled up when wet pastures are grazed in early spring. They ingest forage, chew, salivate, and use their tongues to form a bolus (a package of food) before swallowing. The bolus is much easier to swallow than individual blades of grass. The forage moves down the esophagus into the rumen where it is mixed with rumen fluid and previously ingested feed. Rumen contents are continually mixed and churned by muscle contractions of the rumen wall. This mixing helps ensure optimal feed digestion. In this case, digestion may be a misnomer, as the ingested forage is actually fermented by billions of microorganisms (bacteria and protozoa) in rumen fluid. These microorganisms reduce cellulose and other compounds in the fibrous portion of feed to compounds, such as glucose, that the microflora can use for their own growth and metabolism. However, during microbial fermentation volatile fatty acids (VFA) are produced as by-products of fiber digestion (fermentation). Ruminant animals then use these by-products as part of their daily nutrients for growth and production.

VFAs are the major energy source used by ruminants at the cellular level for body maintenance, growth, and production. The enzyme cellulase reduces cellulose, a complex compound in the fibrous portion of plants, to glucose, a simple sugar, that can be used by microflora or the animal. This enzyme is found only in the microbial world and is not produced by any known mammalian system.

In the rumen, the longer, bulkier material finds its way to the top of the rumen where it is regurgitated as the cud and rechewed. Remastication (cud chewing) is very important because it helps reduce feed particle size, providing a greater surface area for microbial fermentation when the material is swallowed again. More saliva is added during cud chewing than was added during initial feed ingestion. Saliva is critical to the system's health because it is high in sodium bicarbonate, which acts as a buffer to help maintain the ruminal pH at approximately 6.5, the optimal pH for microbial activity in a forage-fed ruminant animal.

Rumen pH maintenance is critical because a decrease or increase in pH will kill all or some rumen microflora. If this occurs, ruminants lose their ability to digest the fiber in feeds, leading to their death due to starvation. Maintaining the rumen pH is accomplished through the saliva's buffering action and continual VFA's absorbency through the rumen wall into the blood stream. VFAs are the major energy source for the animal's cellular metabolism.

The rumen is an open ecosystem–everything that can, does live there. Microflora species reflect a ruminant animal's current diet. It takes approximately 14 to 21 days for the rumen microbial population to change when the diet is shifted from grass to legumes or from forage to grain. Therefore, an adaptation period is needed when ruminant animals' diets are changed. Forage and fiber digestion may be dramatically altered when using other feeds high in soluble energy or protein in the form of supplements. Typically, rumen microflora require diets containing a minimum of 6 to 7 percent crude protein (CP) to ensure optimal microbial growth and optimal fiber digestion. In cases where diet CP levels drop below 6 percent, a corresponding drop in fiber digestion occurs, resulting in reduced animal performance (weight loss). Supplemental protein eliminates this problem. If ruminants are fed easily digested carbohydrates, such as cereal grains, one of two situations results. Ruminants fed an appropriate grain level balanced with CP may experience enhanced microbial activity, resulting in an increase in fiber digestibility and a subsequent increase in animal performance. Ruminants fed too much grain will experience a change in the rumen microfloral population, resulting in reduced fiber digestion decrease and a corresponding weight loss.

The reticulum, like the rumen, serves as an area for fiber fermentation and nutrient absorption. It is the lowest part of the stomach complex and, as a result, is where all heavy items accumulate. Ingested rocks, nails, and wire all find their way into the reticulum and settle there. However, during normal reticular contraction one or more of these sharp objects may penetrate the reticular wall, allowing the rumen fluid to leak into the animal's abdominal cavity. In more pronounced cases of "hardware disease," the sharp object also may penetrate the diaphragm and embed itself in the heart, resulting in immediate death.

Omasum

The third stomach compartment found in ruminant animals is the omasum. Containing a series of muscular bands that help grind and dry ingested food via muscle contractions before it moves into the abomasum, the omasum absorbs digested end products, as well as continues fiber digestion.

Abomasum

Gastric and hydrolytic digestion take place in the abomasum (true stomach) and throughout the remainder of the ruminant digestive tract. In the abomasum, the ingested food, (chyme), containing complex compounds, such as proteins, fats, and carbohydrates, is mixed with mammalian digestive enzymes and hydrochloric acid (HCL). The enzymes and HCL reduce the food nutrients (proteins, fats, and carbohydrates) to amino acids, fatty acids, and simple sugars (glucose) that are absorbed into the blood steam and used by the animal for maintenance and production. When ingested food leaves the omasum, it is at a pH of approximately 6.5. In the abomasum, this pH is quickly changed to 2.5 by the HCL. This low pH is necessary for enzymes to function properly.

Small Intestines

The small intestine joins the abomasum at the pylorus. Enzymatic and chemical digestion and nutrient absorption continue in the small intestine where the pH remains at 2.5.

Large Intestine

The large intestine is the last part of ruminant animals' digestive systems. It absorbs products missed earlier. The first part of the large intestine is a structure called the cecum, in which fiber digestion similar to that in the rumen occurs. In a herbaceous animal, such as a horse, without a rumen, reticulum, or omasum, the cecum is critically important; in others, like cattle, it is not. All animals maintain a population of microflora in their large intestines and, as a result, the pH is approximately 6.5. No enzymes of mammalian origin are produced or excreted in the large intestine. Large amounts of water are absorbed from the large intestine.

It takes food approximately 12 hours to pass through a nonruminant digestive tract. (This also is true for a horse if the cecum is bypassed.) However, it is common to find varying portions of a meal in the rumen 96 hours after consumption. Rumen fill helps regulate intake; therefore, material must pass out of the full rumen before the ruminant animal can graze more. Plant maturity plays a major role in rumen turnover time. Immature, high-quality forage moves out of the rumen quickly, while mature plants—high in fiber—stay in the rumen for extended periods.

Feed Components

Feedstuff composition, such as water, carbohydrate, protein, and fat, helps determine how cattle perform. Figure 2 illustrates how feed is broken down into its component parts in a laboratory procedure called proximate analysis. When feeds are submitted to a laboratory for chemical analysis, this procedure is commonly used. The producer or a consultant must interpret the results and devise a suitable ration for the animals and the situation in question.

Thousands of chemical analyses have been performed on commonly used feeds, with the averages for various qualities within the same feed type compiled in standardized feed analysis tables. These tables contain

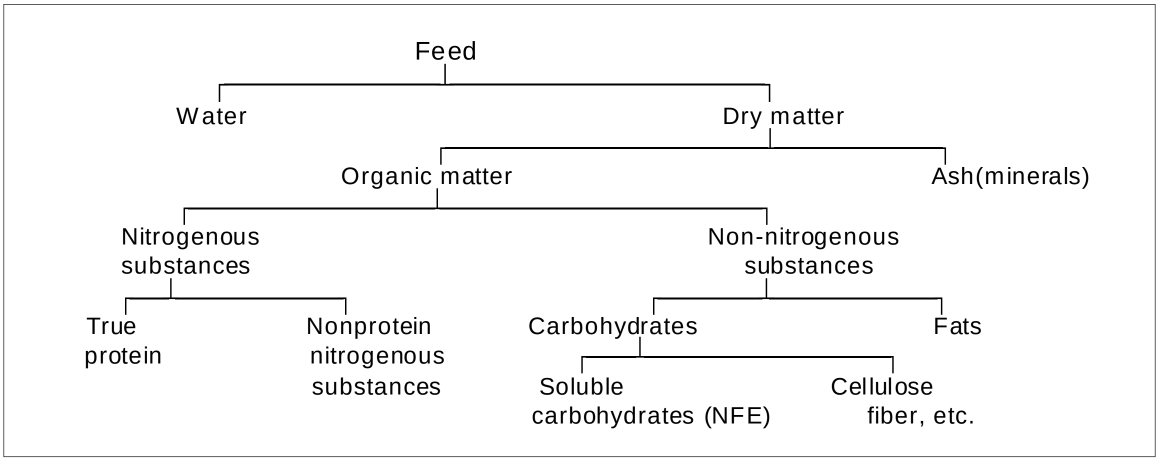


Figure 2. Food components.

sound information and are often more reliable than analysis of a single feed sample that may not represent a valid value for the feed due to improper sampling techniques and/or errors. Standardized feed tables are frequently sample composites from across the country and, therefore, may tend to under- or overestimate the actual value of feed

This producer is gathering hay samples from different sections within the stack to ensure analysis is based upon a representative composite sample.

from a specific area. An analysis of a native plant or plants gathered in the field to simulate the diet of grazing cattle leaves room for doubt because cattle are very selective and may be eating only certain high-quality plants or plant parts rather than the plant material composites typically collected for lab analysis. Analysis of harvested crops, such as hay, is worth the expense, as nutrients vary according to geographic location and management practices such as fertilization, irrigation, and plant maturity at harvest.

Water

The water content of feeds causes great variation in their nutritive value; this is especially true of farm or feedlot rations where high-moisture silage is often fed. However, water content also influences cattle performance under range conditions when cattle are turned onto spring grass. During the rapid-growth period in early spring, grazed native forage contains 75 to 90 percent water. If a lactating cow requires 27 pounds of dry matter per day, she will need to graze between 108 and 270 pounds of grass, depending upon its water content, to meet her dry matter requirement. In this case, the cow is only consuming 27 pounds of dry matter along with 81 to 243 pounds of water, or approximately 10 to 30 gallons. The cow can adjust the amount of water she drinks daily to reflect the moisture content of the feed. Thirty gallons is above the cow's daily water requirements, while 10 to 12 gallons is closer to what she will actually drink. It would be impossible for the cow to find, graze, and digest 270 pounds of spring forage in a 24-hour period. For this reason, incorporating early maturing, cool-season grasses, such as crested wheatgrass, into a grazing scheme may be a valuable tool to increase the dry matter of early spring forage.

Water quality also can affect adequate consumption. Factors affecting the water quality livestock consume include total dissolved solids, hardness, sulfates, nitrates, and sodium. Salinity often can be a problem, as water is a good solvent and may contain dissolved inorganic salts. Various salts may affect grazing animals, and young animals are more susceptible to the effects of these salts than more mature animals. Hot weather naturally increases water consumption; therefore, changing cattle from high-quality water in one pasture to water containing large amounts of saline in another pasture during a normal pasture rotation can create problems. Developing alternate water sources is one way to alleviate this problem. Cattle returned to high-quality water recover rapidly from the ill effects of salts. The nitrate content of water is seldom a problem unless combined with high-nitrate content feeds. This problem occurs primarily during drought or winter periods when harvested feeds, such as hays, are being fed and water may be limited (i.e., freezing).

Most waters are alkaline with pH values of 7.0 to 8.0. Although little is known about the effects of higher alkalinity, water with a pH of 10 or higher must be viewed as suspect and a possible hazard to animals.

Total dissolved solids (TDS) consist of inorganic and organic materials. When a water sample is submitted for analysis, results are generally reported in parts per million (PPM) or the megaliter of the tested solids. Several different references report safe levels. A typical composite water sample analysis is shown below. It does not involve abrupt changes in content.

Substance	Can tolerate in PPM or Megaliter	Danger in PPM
Total dissolved solids	7,000 or less	7,000 or more
Sodium or salt	3,000 or less	3,000 or more
Nitrates as N	200 to 300	300 or more
Alkali (hardness)	1,000 or less	Unknown

Note: Alkaline water may or may not be saline. Some alkaline waters are referred to as hard water because they contain calcium, iron, and magnesium but not sodium.

For water testing, write or call: Wyoming Analytical Laboratory
1660 Harrison Street
Laramie, WY 82070
Phone: (307) 742-7995

Note: Testing requires 1 gallon of water in a clean container. The cost is $60. Do not wash the container with any soap before collecting the water sample because soap frequently leaves a residue that may alter analytical results.

The quality of livestock water can change as the season progresses, and due to mineral concentration and palatability, animal production may be affected.

Carbohydrates

Carbohydrates supply most of cattle's energy needs and make up 65 to 75 percent of the dry weight of grains, forages, and roughage. Carbohydrates include compounds such as sugars, starch, cellulose, and other related substances. Two commonly used substances detected in typical feed analysis to evaluate carbohydrate content of feed are crude fiber and nitrogen-free extract. Feed digestibility generally decreases as crude fiber content increases. In actively growing grass, forage, or high-quality hay, the crude fiber is lower, so digestibility is higher. However, as plants mature, crude fiber content increases and digestibility declines.

Microorganisms in the rumen (10 billion per gram of contents) digest or break down cellulose, the major carbohydrate in the crude fiber portion of plants, into products ruminant animals can use. This symbiotic relationship between ruminant animals and the rumen microflora allows otherwise unmarketable fibrous materials to be converted into useful products such as red meat, milk, and wool. Without microflora in the rumen, reticulum, and omasum this use of fibrous materials in plants by animals would not be possible.

Protein

Proteins are complex compounds composed of various amino acids. These amino acids contain 16 percent nitrogen in addition to carbon, hydrogen, and oxygen. In laboratory feed evaluations, the crude protein content is estimated by measuring the feed's nitrogen concentration, then multiplying it by 6.25. Adequate levels of protein are important for growth, reproduction, and lactation in animals. Without adequate protein, these productive functions are reduced or stopped completely.

High-quality alfalfa hay is an excellent protein source when compared with grains such as corn, sorghum, barley, or oats. Oil seed meals that include cottonseed meal, soybean meal, and canola meal are excellent protein sources to use in a supplementation program for range cattle. Overfeeding protein is very costly, especially if the protein is purchased as a supplement. If excess protein is in a home-raised feed, such as alfalfa, blend lower quality protein hay with it. Excess dietary protein in ruminant animals is broken down and used as an energy source. This process is, however, very inefficient. Cattle maintained under range forage conditions should only be fed protein supplements containing natural proteins. Nonprotein nitrogen (NPN) compounds, such as urea and ammonia, are frequently placed in protein supplements fed to ruminants to reduce the cost of supplementation. NPN products, however, do not provide for the level of performance under range forage conditions that result from all-natural protein supplements. In some cases, feeding supplements containing NPN compound to forage-fed ruminants may result in toxicity and death.

Protein digestion in ruminants is complicated and often an inefficient process. Dietary protein is ingested into the rumen, where the microflora break it down and use the nitrogen portion to synthesize microbial protein, which forms microbial cells within the microbes. As feed material and rumen fluid move through the rumen, reticulum, and omasum to the lower digestive tract, several microbial cells are carried with them. These cells are digested in the abomasum and small intestine. As a result, microbial protein fragments and amino acids are used by ruminant animals for protein synthesis. Every time a protein is broken down and re-formed, energy is required. The rumen microorganisms take poor-quality protein, break it down into elemental nitrogen, then rebuild high-quality microbial protein from this nitrogen; however, this process requires energy. Certain proteins, such as those found in blood meal and feather meal (bypass proteins), may escape microbial break down in the rumen and are digested in the abomasum and small intestine.

Technology has perfected ways to protect high-quality proteins, such as those found in soybean meal, from breaking down by the rumen microbes. Bypass proteins provide an effective method for improving performance of those animals maintained on low-protein feeds. To ensure optimal forage digestion, the rumen microflora must be provided 6 to 7 percent protein in the consumed feed. When using bypass protein, make sure the rumen microflora get 6 to 7 percent protein to optimize forage digestion. The rest of the dietary protein is digested lower down the system, without the losses that occur when protein is broken down by the microbes, reformed into microbial protein, and then broken down again by the animal.

Fats and Oils

Fat is determined in the proximate analysis procedure using an ether extraction. Fat provides approximately 2.25 times the amount of energy per unit of weight when compared with carbohydrates or proteins. The fat content in roughage is low; therefore, fat in range beef cattle diets may be minor when compared with feedlot situations where large amounts of grain and oilseed meals are used in rations along with added amounts of supplemental fats. Elevating the fat content in feeds reduces dust, while increasing palatability and acceptability to range livestock.

Adding fat helps bind cube and pellet ingredients together to make them harder and more stable during handling and feeding. However, care must be taken to ensure the supplement is not too hard for the animals to eat or that the level of fat is high enough to create a rancid feed.

Minerals

Minerals are critical for skeletal development, digestion, metabolic processes, reproduction, growth, and lactation.

Research has shown that seven major and six trace minerals are required daily for normal health and well-being of grazing animals. These minerals are not synthesized by the animals and must be provided in their daily diets. Calcium and phosphorus are two of the most important minerals animals require on a daily basis. Ninety-nine percent of calcium is localized in animals' bones and teeth, while 80 percent of phosphorus is found in their skeletons. The remaining 20 percent of phosphorus is found in the soft tissues where it plays a major role in cell metabolism. Generally, roughage and forages are high in calcium, but low in phosphorus, while grains tend to be high in phosphorus and low in calcium. Therefore, range cattle generally exhibit adequate intakes of calcium, while their phosphorus intakes are low and should be supplemented to ensure optimal performance. Phosphorus is bitter and unpalatable when fed by itself. Therefore, mix phosphorus sources with salt. Animals will get the phosphorus while consuming salt, which provides them sodium and chloride.

Phosphorus supplementation has been shown to increase reproductive efficiency and milk production in forage-fed cattle. The lack of trace minerals is frequently an area problem. Cobalt, copper, and zinc are sometimes deficient in feedlot rations. The trace element copper can be extremely toxic at high levels; yet, under some range situations, supplementation has improved cattle performance.

Vitamins

Vitamins are generally grouped according to their regulatory functions and are not necessarily chemically related. Vitamins help animals digest and absorb nutrients. Vitamin A is commonly provided by injection or through supplementation, and animals can store up to a six-month supply of vitamin A in their livers. If they have been on green feed for an extended period, animals should have adequate vitamin A. However, if animals are maintained on dried, bleached feed for extended periods, vitamin A supplementation may be warranted.

Energy Calculation

The amount of energy feed provides is calculated from a feed analysis as follows and is represented as Total Digestible Nutrients (TDN):

Starches and sugars (NFE) x Digestibility (50 percent ±)	= X percent
Crude fiber x digestibility	= X percent
Protein x digestibility	= X percent
Fats x 2.25 x digestibility	= X percent
Total	= TDN

Digestibility is based on actual animal feeding trials. In contrast, the laboratory values determined are actually averages of the chemical data collected. Therefore, determining the energy content of a feed (TDN) actually becomes an estimated value as a result of the arithmetic process.

Examples of feed analysis on two different feeds are provided and illustrate the differences between forages and grains. Make note of the energy values, the fiber content, and the calcium content of each. Grain is often viewed as a supplement for a protein deficiency in a diet. The observed differences shown between the forage and corn dismisses this practice as unacceptable.

WDA.228/Rev. 4/89

WYOMING DEPARTMENT OF AGRICULTURE

Chemical and Bacteriological Laboratory
1174 Jackson Street
Laramie, Wyoming 82070

No. 30739

90-01301 &
90-01302

SERVICE SAMPLE ANALYSIS REPORT

Product: Timothy hay, early cut

Sent in By: Jol E. Rancher

Analysis Requested: Total Analysis

Remarks: Copy to University Agent

Date Sample Received in laboratory: November 13, 1997

ANALYSIS: In Percent

Dry´Matter	Crude Protein	Ether Extract	Fiber	Cal.	Phos.	TDN
89.1	9.7	2.5	30.2	.46	.26	53.0

WDA.228/Rev. 4/89

No. 30739

WYOMING DEPARTMENT OF AGRICULTURE

Chemical and Bacteriological Laboratory
1174 Jackson Street
Laramie, Wyoming 82070

90-01301 &
90-01302

SERVICE SAMPLE ANALYSIS REPORT

Product: Corn Grain, cracked

Sent in By: Jol E. Rancher

Analysis Requested: Total Analysis

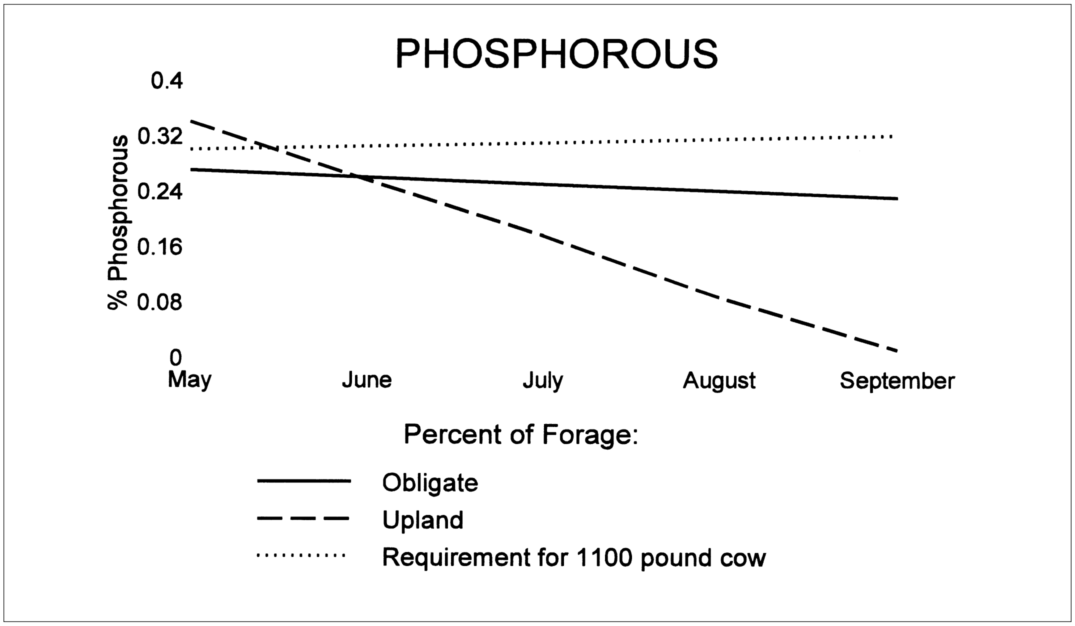
Remarks: Copy to University Agent

Date Sample Received in laboratory: November 13, 1997

ANALYSIS: In Percent

Dry Matter	Crude Protein	Ether Extract	Fiber	Cal.	Phos.	TDN
90	8.8	3.65	2.1	.027	.29	90.0

Figure 3. The phosphorous content of native forage declines rapidly in upland species as the season progresses. Although the phosphorous level in riparian plants is more constant, it is less than the cow's requirement.



Chapter 4

Nutritional Requirements and Production

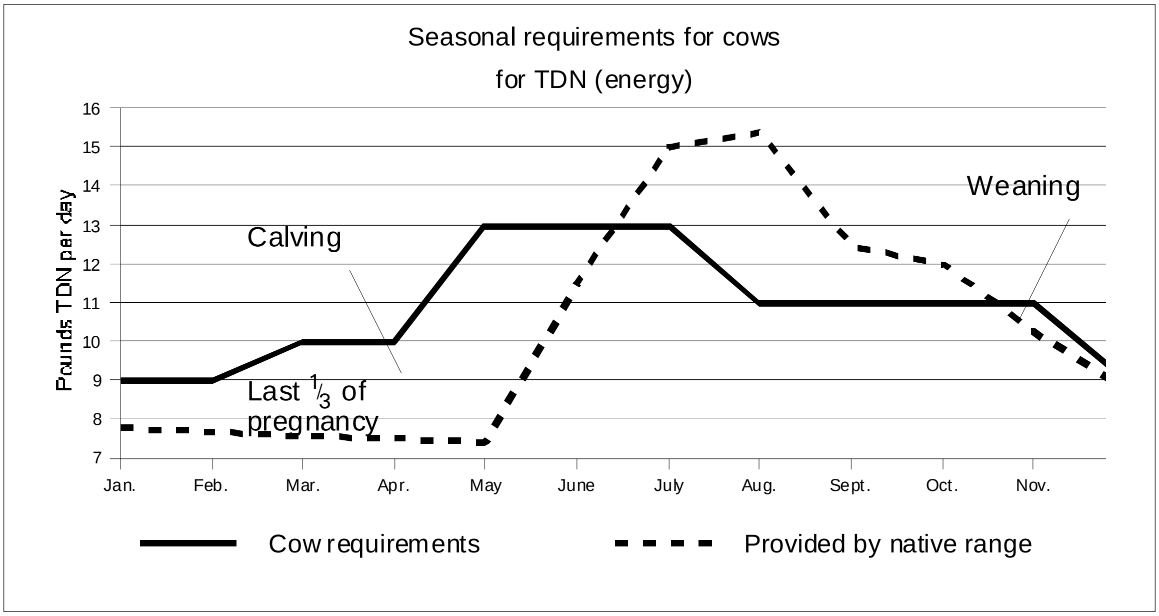
The daily energy, crude protein, and mineral requirements for beef cattle have been researched for many years and, with small revisions, have been published often. Rations for cattle in the feedlot can be determined more precisely because there is more control of the animals' daily feeding programs. Table 1 shows the daily requirements of beef cows as determined by the National Research Council (NRC) under more or less controlled situations.

Table 1. Nutritional requirements for beef cows (NRC).

			CP		TDN	
Weight	Gain, lb.	Daily ADF, lb.	lb.	Percent of ration	lbs.	Percent of ration
Mature cow - (middle third of pregnancy–25 percent of fetal weight)						
1,000	0	20	1.3	6.5	8.8	44
1,100	0	22	1.4	6.5	9.7	44
1,200	0	23	1.4	6.5	10.0	44
Mature cow - (last third of pregnancy–70 percent of fetal growth occur here)						
1,000	.9	22.0	1.6	7.2	10.5	48
1,100	.9	23.5	1.6	7.0	11.2	48
1,200	.9	25.0	1.7	7.0	11.8	48
Cows nursing calves (average milk production 12 lbs./day)						
1,000	0	23-25	2.0	8.8	12.6	56
1,100	0	25-28	2.0	8.3	13.5	56
1,200	0	27-30	2.1	8.2	14.3	56
Pregnant yearling heifers (last third of pregnancy)						
700	1.4*	18	1.4	8.0	9.5	54
750	1.4	19	1.5	8.0	10.0	54
800	1.4	20	1.5	8.0	10.5	54
850	1.4	21	1.6	8.0	10.8	54

*Body weight gain only. Total gain with fetus is about 1.4 pounds. This provides for approximately a .4 pound gain for the heifer herself and a 1 pound per day for the fetus and products of conception. This weight gain will help ensure the heifer milks well and breeds back for her second calf.

Note: ADF = Air Dry Feed, 90 percent dry matter or as fed; CP = Crude Protein; TDN = Total Digestible Nutrients (an estimate of energy needs)



Graph 1. Other nutrients follow a similar trend.

As cows approach calving, energy and protein requirements increase. After calving, the increased nutrient demand associated with lactation can cause requirements to increase to approximately 78 percent for protein and 17 percent for energy. This increase is shown as TDN (energy) in Graph 1 for cows calving in March and early April (solid line). The dotted line indicates the amount of TDN provided by native range.

In January, native range forage provides slightly less than 8 pounds of TDN daily to the grazing pregnant cow whose requirement is approximately 9 pounds. By the time cows are turned out on spring grass in May, their TDN needs have increased to 13 pounds per day, while the grazed forage is only able to provide approximately 7.5 pounds of this need. This deficiency must be made up by feeding a supplement or harvested forage. If hay has a value of $85 per ton, the cost of eliminating this deficiency can be quite high.

Moving the calving period to later in the spring or early summer, when forage nutrient levels more closely match the pregnant cow's needs, may provide an acceptable alternative to large supplemental feed bills. Later calving means potentially lighter calves at weaning; however, this is offset by less labor at calving, fewer calf losses and sick calves, and less harvested feed needed for cows. Current research suggests that feed saved by later calving increases the net return from $23 to $29 per cow per year. These values do not include the savings from less labor, less veterinarian expenses, and lower calf death rates. A savings of $25 translates to $5 per hundredweight at market for a 500-pound calf.

Nutritional regimes provided during precalving and postcalving directly affect the cow herd's rebreeding efficiency. Following calving, there is an 82-day window during which the cow must lactate (peak milk production in beef cattle typically occurs 60 days postcalving) and rebreed. First estrus typically occurs 35 to 40 days after calving. If nutrients are adequate, this leaves approximately 42 days, or two estrous periods (21 days per period), for the cow to get pregnant (if she is to maintain a yearly calving interval). In situations where nutrients are limited during this time, many cows, especially the younger (2 to 4 year olds), will show up as short breds or opens at fall pregnancy testing. Many studies have been conducted on various nutrition levels pre- and postcalving. All studies have shown essentially the same results; if nutrients are to be limited, this should happen before the last 90 days before calving. The results of research that limited nutrients prior to calving are presented in Table 2.

The fall scoring of cow condition on a scale of 1 (thin) to 9 (fat) is a practical method to determine the winter nutrition level cows need. This method allows cows to be sorted into groups that have similar nutritional needs during the upcoming winter period.

The effect of either low- or high-energy levels pre- and postcalving is shown in Table 3.

A cow's condition score at the beginning of winter has other ramifications. Practical experience has demonstrated that a cow with a condition score of 5 at the beginning of winter requires approximately 50 percent less feed than one with a fall condition score of 3.5. The higher scoring cow will more aggressively forage for standing crop forage or windrowed hay on its own, digging through the snow if necessary, while the

Table 2. Effects of precalving energy levels (first calf heifers).

	Pre-calving TDN level	
	5.7 lb. (Moderate)	8.8 lb. (NRC Recommended)
Weight change, pound	-13	80
Days to first estrus after calving[1]	52	51
Estrus at 40 days, percent	26	41
Calf birth weight, pound	63	67
Assisted births, percent	28	27
Calves alive at birth, percent	90	97
Weaning weight, pound	325	354

[1] Estrus - period of male receptivity. Estrous cycle - period from the end of one estrus period to the start of another. Averages 18 to 21 days in cattle.

Table 3. Nutrition effects on weight gains and reproductive performance of heifers.

Nutritional level				Weight gain of heifer (pound)	Conceiving first service (percent)	Cows pregnant (percent)
Before calving	lbs. TDN	After calving	lbs TDN			
Low	4.5	Moderate	8.0	1.10	51	80
Low	4.5	High	16.0	2.16	71	91
High	9.1	Low	4.5	-.50	42	68
High	9.1	Moderate	8.0	.65	63	77
High	9.1	High	16.0	1.75	62	87

Table 4. Feed composition tables.

Feed	Air dry roughage (Assume 90 percent D.M.) CP	TDN
	percent	percent
Alfalfa – early bloom	16.5	51.3
– mid-bloom	15.4	50.0
– full-bloom	14.3	48.0
Brome grass hay – early	14.0	50.0
– mature	6.0	48.0
– early growing	21.0	74.0
Alfalfa-brome mix – first cut	13.5	49.0
Meadow hay (mixed) – early cut	8.3	47.0
Oat hay with some grain	8.1	53.6
Sweet clover hay – mid-bloom	14.0	50.0
Timothy – mid-bloom	7.5	50.0
Crested wheat grass – fullbloom	4.5	30.0
Mature range	4.1	34.0
Kentucky bluegrass (early fresh)	17.4	72.0
Native grasses (early fresh)	9.0-11.0	64.0-74.0
	Grains (other low protein concentrates)	
Barley, grain	11.6	74.0
Corn number 2	8.9	81.0
Ground ear corn	8.1	78.0
Oats, grain	11.9	68.0
Wheat, grain	12.7	78.0
3-way mix (corn, oats, and barley)	9.0	72.0
70 X 30 pellet (alfalfa and corn)	13.02	57.0
80 X 20 cube (alfalfa and corn)	14.1	56.0
	CP	TDN
	High protein supplements	
Cottonseed meal (solvent process)	42.0	73.0
Soybean meal (solvent process)	46.0	72.0
Commercial mix 20 percent (all natural)	20.0	66.0
Commercial mix 32 percent (all natural)	32.0	64.0
Commercial mix 50 percent (all natural)	55.0	64.0

Note: The TDN of commercial mixes varies according to the base and filler materials used.

lower scoring cow becomes dependent on supplemental feed and is a less efficient forager. This results, in part, to less back fat on the condition score 3.5 cow and subsequently greater stress for this cow as temperatures fall to zero and below.

Table 4 lists the average crude protein and TDN content for common feeds.

Factors Contributing to Hay Consumption

The amount of hay a cow will actually consume depends upon its size, condition, production stage, and milking ability, as well as availability of supplemental feed, hay digestibility, and environmental conditions. High-quality roughages, such as alfalfa hay, pass through the digestive tract faster than dormant cured range forage or straw. Although the NRC requirements provide daily feed levels to meet energy needs for a given production stage, there is no assurance that a cow will be able to eat that much feed if it is poor quality. If fed high-quality feed, a cow can easily meet her needs with smaller amounts of feed; therefore, she may still appear hungry and discontented. In these cases straw or poor-quality grass may be fed to ease the cow's desire to eat. Producers must work diligently to ensure that the cow's nutrient level is met, the cow is satisfied, and no feed nutrients are wasted. Ordinarily, daily consumption by a beef cow varies between 1.5 to 3 percent of body weight, depending upon her production stage. Table 5 shows estimated consumption rates for several hays of various qualities.

Data in Table 6 illustrate that meadow hay with less than 4 percent crude protein content and associated TDN values is marginal for meeting the nutritional

Table 5. Roughage capacity of beef cows (900 to 1,100 pounds).

Roughage type	Class of cattle	Dry matter intake	As fed intake
		percent	pounds
Low-quality roughages	Dry cows	1.5	17-18
(dry grass, straw, etc.)	Lactating cows	2.0	23-24
Average-quality hays	Dry cows	2.0	22-24
(meadow, native grass, etc.)	Lactating cows	2.3	25-28
High-quality forages	Dry cows	2.5	28-30
(alfalfa hay)	Lactating cows	3.3	30-32
Green pasture forage	Dry cows	2.5	80-100
	Lactating cows	2.7	100-110

Note: Hay nutrient quality varies not only between types but also within types, depending upon the hay's stage of maturity at harvest. Producers realize that as a hay crop matures, its nutrition level decreases.

requirements of a cow during the last trimester of pregnancy. There is no room for cheating on daily amounts fed, as this is all the cow can consume. With the exception of hays containing 5.5 and 5.8 percent CP, hays fed at 22 pounds per day fail to meet the CP needs of the rumen microflora, which impacts fiber digestion and subsequent animal performance.

Hay quality is not the only factor affecting cattle nutrient intake. The average environmental temperature also influences feed intake and its digestibility. Table 7 shows the effect of seasonal temperatures on total feed intake and its digestibility relative to an average daily temperature of 65 degrees Fahrenheit. Shelter was available to the cattle in this study.

Table 6. Crude protein and total digestible nutrient content of meadow hay (Nebraska data).

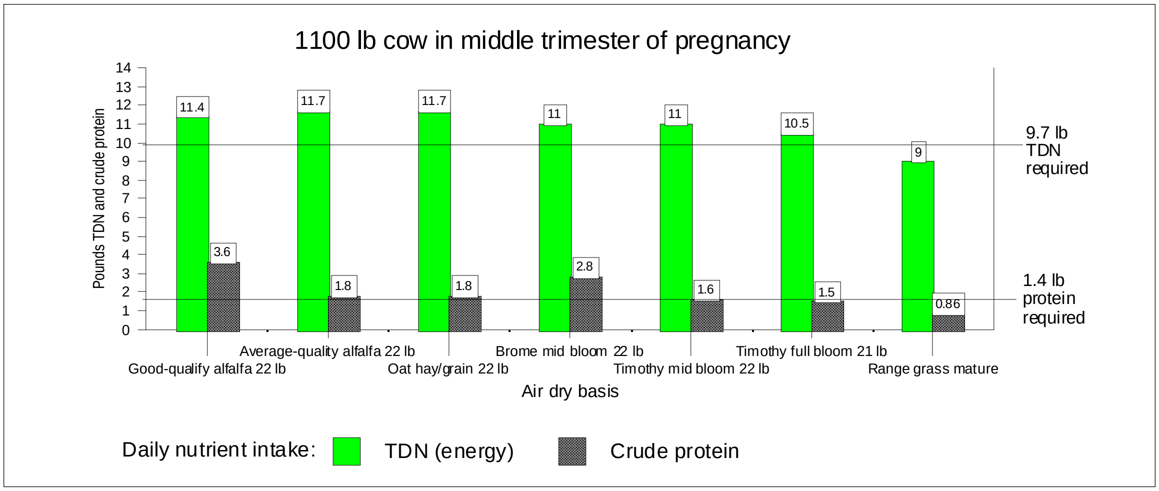
Protein content (percent)	TDN (percent) by 22 lbs. hay	Pounds TDN provided by the hay for last trimester of pregnancy*	Percent of TDN requirement (NRC) provided by the hay
3.01	41	9.0	86
3.20	45	9.9	94
3.93	47	10.3	98
4.0	50	11.0	101
4.2	50	11.0	101
4.6	53	11.7	111
4.7	53	11.7	111
5.5	52	11.4	108
5.8	56	12.3	117

* 1,000 pound cow

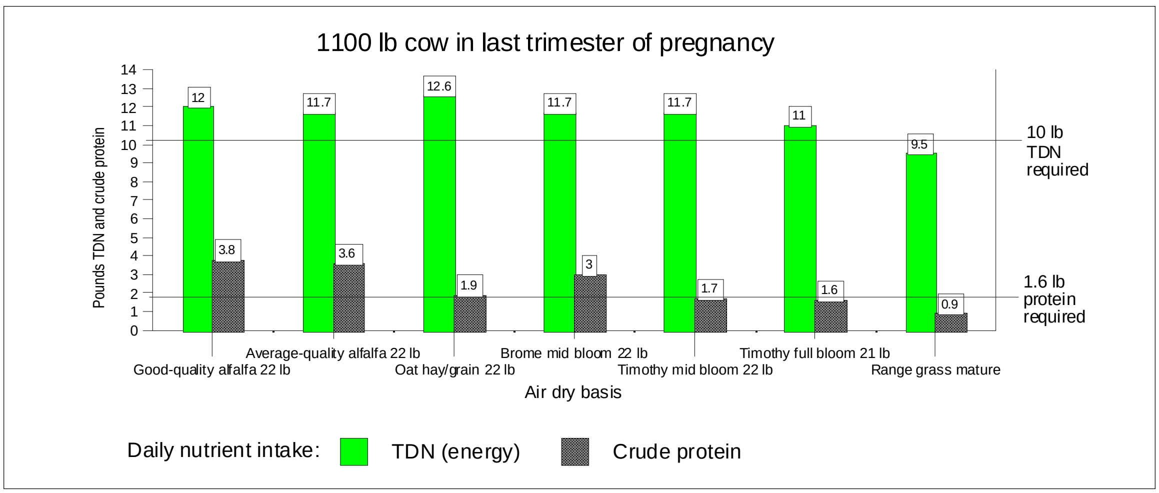
Table 7. Effect of temperature on feed intake and its digestibility by cattle.

Month	Total feed intake (pounds)	Digestibility (percent)	Feed intake relative to 65 degrees (percent)
July	20.4	69.9	100
August	20.6	69.5	101
September	21.2	68.3	104
October	21.9	67.0	108
November	23.1	64.7	114
December	24.1	63.1	119
January	24.6	62.1	121
February	24.0	63.2	118
March	23.3	64.3	115
April	22.0	66.6	108
May	21.1	68.3	104
June	20.7	69.2	102

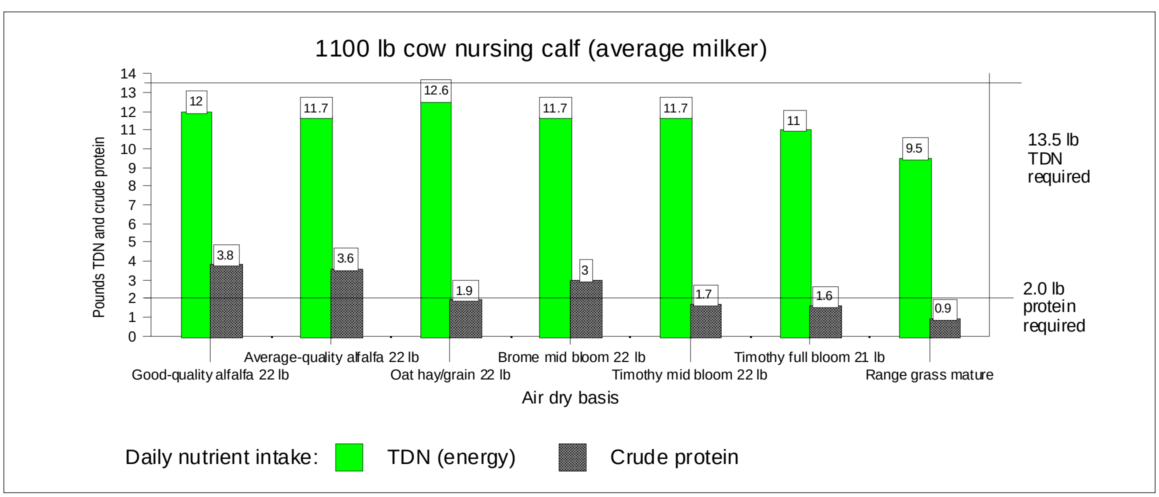
Graphs 2, 3, 4, and 5 show a cow's requirements for the middle and last trimesters of pregnancy and lactation.



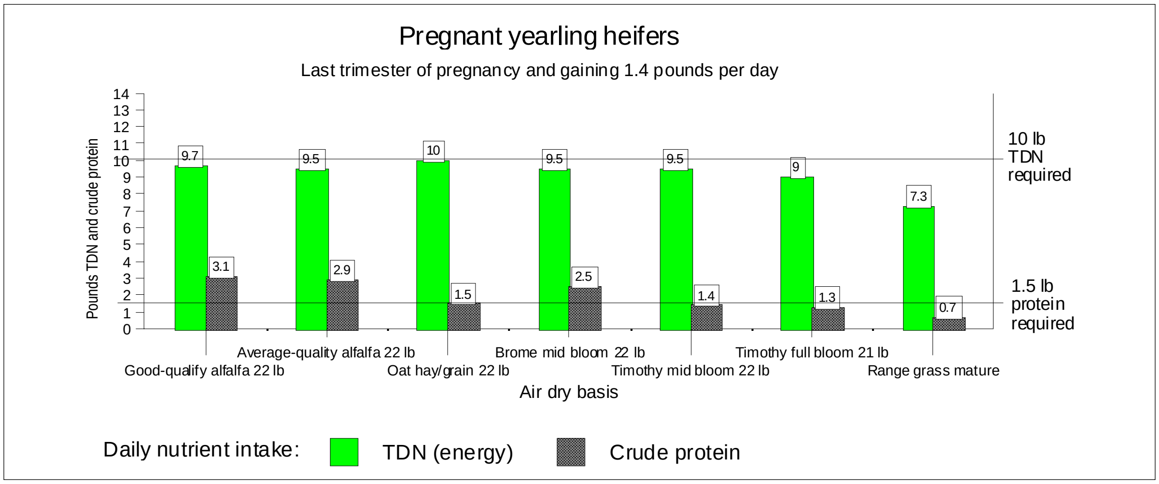
Graph 2.



Graph 3.



Graph 4.



Graph 5.

These graphs serve as a rule of thumb reference. High-quality hays are not likely to be deficient in TDN or protein, while late-cut or low-quality roughage often provides an inadequate level of TDN and/or protein for pregnant cows and growing heifers. After calving, all hay becomes marginal for energy and some hay becomes marginal for protein unless a cow's intake increases. Some energy supplementation may be required for growing heifers but can be accomplished only with high-quality hay containing adequate protein. An effective management practice is to save the best hay for postcalving or for young growing animals.

An important part of breeding herd management is to grow replacement heifers so they attain puberty and breed in a way that allows them to fit into the cow herd easily. Puberty varies between breeds and is a function of both age and weight. Typically, a heifer should weigh 65 percent of her mature weight by the onset of her first breeding season. In addition, the heifer should demonstrate estrus 45 days prior to the beginning of the breeding season. This young female is still growing and, therefore, requires a nutritional regime following calving over and above that needed for just maintenance and lactation. Failure to meet all of her nutritional needs can result in her failure to breed for her second calf in a timely manner. Producers often face the problem of an inordinate number of open (nonbred) cows among their second calf heifers because nutritional requirements were not met at the correct time. Research has shown heifers that first calve as 2 year olds raise one more calf during their lifetimes than cows that first calve as 3 year olds. Table 8 shows average ages and weights at which various crossbred cattle reached puberty.

Table 8. Age and weight at puberty for crossbred heifers of different breed types.

	Age (days)	Weight (pounds)
Jersey cross	308	518
Gelbvieh cross	326	626
Brown Swiss cross	332	615
Pinzgauer cross	334	611
Red Poll cross	337	580
Tarentaise cross	349	622
South Devon cross	350	639
Hereford-Angus cross	357	622
Maine-Anjou cross	357	622
Simmental cross	358	666
Limousin cross	384	679
Chianina cross	384	699
Charolais cross	384	699
Sahiwal cross	414	642
Brahman cross	429	712

Note: These weights represent 65 percent of the estimated mature weight of the cow.

Growing Heifer Calves for Spring Breeding

The following scenario assumes:

1. Crossbred Hereford-Angus heifer calves are weaned on October 15 at 450 pounds. The weaning method determines a shrink before calves stabilize and adapt. Assume a 15-pound loss (shrink), for a net weight of 435 pounds.
2. Plan to begin calving near (assume a 283 day gestation period)
   a) February 15–begin breeding May 8
   b) March 15–begin breeding June 5
   c) May 15 - begin breeding August 5
3. Reach weights of 625 pounds or more before the above dates, which equals 190 pounds of gain or
   a) 0.93 pounds per day gain by May 8 (205-day growing period)
   b) 0.82 pounds per day gain by June 5 (233-day growing period)
   c) 0.65 pounds per day gain by August 5 (294-day growing period)

Considering the effects of cold weather, storms, and other factors, a target weight gain of about 1 pound per day is reasonable for the May 8 breeding date compared with 0.82 pound per day for the March 15 calving date. In contrast, May calving requires the heifer to gain considerably less weight per day during the winter growing period prior to August breeding.

If a calf weighs 450 pounds at the beginning of the feeding period and the desired weight 100 days later is 650 pounds, then the average weight of this calf halfway through the feeding period should be 550

Table 9. Requirements for growing heifers (air dry or as fed basis).

Weight	Daily gain	ADF-BW		CP		TDN	
(pounds)	(pounds)	(pounds)	(percent)	(pounds)	(percent of ration)	(pounds)	(percent of ration)
Heifer calves - medium frame							
300	1.0	9.0	3.0	.91	10	5.0	56
350	1.0	10.0	2.8	.96	9.6	5.6	56
400	1.0	11.0	2.7	1.01	9.2	6.2	56
450	1.0	12.0	2.6	1.06	8.8	6.7	56
500	1.0	13.0	2.6	1.11	8.5	7.3	56
550	1.0	14.0	2.5	1.15	8.2	7.8	56
600	1.0	15.0	2.5	1.20	8.0	8.4	56
Heifer calves - medium frame							
350	1.5	10.2	2.9	1.12	10.9	6.3	62
400	1.5	11.3	2.8	1.17	10.3	7.0	62
450	1.5	12.4	2.7	1.21	9.7	7.7	62
500	1.5	13.4	2.7	1.25	9.3	8.3	62
550	1.5	14.4	2.6	1.28	8.8	9.0	62
600	1.5	15.3	2.6	1.32	8.6	9.5	62
650	1.5	16.3	2.5	1.36	8.3	10.0	62
700	1.5	17.2	2.5	1.40	8.1	10.7	62
Heifer calves - large frame (and yearlings)							
350	1.5	10.9	3.1	1.18	10.7	6.3	58
400	1.5	12.1	3.0	1.23	10.0	7.0	58
450	1.5	13.2	2.9	1.27	9.6	7.6	58
500	1.5	14.3	2.9	1.32	9.2	8.3	58
550	1.5	15.4	2.8	1.36	8.8	9.0	58
600	1.5	16.4	2.7	1.41	8.6	9.5	58
650	1.5	17.4	2.7	1.45	8.3	10.0	58
700	1.5	18.4	2.6	1.50	8.1	10.7	58
Heifer calves - large frame (and yearlings)							
350	1.0	10.5	3.0	1.00	9.5	5.6	53
400	1.5	11.6	2.9	1.06	9.1	6.1	53
450	1.0	12.7	2.8	1.11	8.7	6.7	53
500	1.0	13.7	2.7	1.16	8.5	7.3	53
550	1.0	14.7	2.7	1.20	8.1	7.8	53
600	1.0	15.6	2.6	1.25	8.0	8.3	53
650	1.0	16.6	2.6	1.30	7.8	8.8	53
700	1.0	17.6	2.5	1.34	7.6	9.3	53

ADF = Air Dry Feed, 90 percent dry matter or as fed, CP = Crude Protein,

Percent BW = Daily feed as a percent of body weight pounds. The total period gain is 200 pounds in 100 days or 2 pounds per day, so, in this example, the ration would be based on a 550-pound calf gaining 2.0 pounds per day. Rations are based on the calf's production level, as well as her body weight. Rations for growing calves are based on the desired rate of gain and their body weight halfway through the feeding period. The amount of feed a calf may be expected to consume daily is shown in table 10.

Rule of thumb guides for relative amounts of hay and grain in a ration are presented as two different scenarios in sets 1 and 2. One ration uses high-quality hay while the other uses fair- to poor-quality hay. The second ration requires a protein supplement in addition to grain to meet the calf's nutritional needs.

As the calf grows, the daily feed consumption will increase, and the hay to grain ratio will remain similar, but the amount of feed consumed daily as a percent of body weight will decrease.

Table 10. Growing calves – medium frame (adjust up .1 percent for larger frame).

Weight (pound)	BW (percent)	Daily as fed consumption (pound) (includes some waste)
300	3.10	9.5
350	3.00	10.5
400	2.90	11.5
450	2.80	12.5
500	2.70	13.5
550	2.65	14.5
600	2.60	15.5
650	2.50	16.5
700	2.45	17.5

Set 1. Estimated roughage and grain ration for calves to gain at various rates.

450-pound calves fed high-quality hay
Hay - 50 percent TDN and 15.4 percent crude protein
Grain - 78 percent TDN and 9.0 percent crude protein

Daily gain (pounds)	As fed feed per day (pounds)	Requirement: Average TDN (percent)	Requirement: Crude protein (percent)	Percent of ration: Roughage (percent)	Percent of ration: Grain (percent)	Grain (lb)
.0	12-13	48	7.2	100	0	0
.50		50	8.6	100	0	0
.75		52	8.7	90	10	1-2
1.00		54	9.0	80	20	2-3
1.50		57	10.0	75	25	3
1.75		59	10.4	70	30	4
2.00		61	10.8	65	35	4-5

Note: No protein deficiency occurs in these rations at 2 pounds per day gain.

Set 2. Estimated roughage and grain ration for calves to gain at various rates.

450-pound calves fed fair- to poor-quality hay
Hay - 42 percent TDN and 5 percent crude protein
Grain - 78 percent TDN and 10 percent crude protein

		Requirement		Percent of ration			
Daily gain (pounds)	As fed feed per day (pounds)	Average TDN (percent)	Crude protein (percent)	Roughage (percent)	Grain (percent)	Grain (pounds)	32 percent all natural CP supplement required (pounds per day)
.0	12-13	48	7.2	85	15	2.0	.50
.50		50	8.6	75	25	3.0	1.00
.75		52	8.7	70	30	3.5	1.25
1.00		54	9.0	65	35	4.5	1.25
1.50		57	10.0	60	40	5.0	1.50

Wintering calves depend upon the appropriate ratio of energy (grain) to the protein level to gain weight.

Chapter 5

Supplementation and Substitution

Livestock supplementation should not be confused with substitution. In either case, additional feed is provided, but the circumstances that prompt each procedure are very different. Unfortunately, the valuable practice of supplementing dietary nutrient deficiencies in livestock rations receives incorrect interpretations.

Substitution can be defined as putting or using in place of another or taking the place of something. If no native forage remains and hay is being fed, the hay serves as a nutritional substitute. Supplementation is defined as something that completes or makes an addition to something. If sufficient native forage is available but is in dormancy or is poor quality and a commercial product is being fed, the commercial product is a nutritional supplement designed to correct a deficiency in the forage.

The following research information illustrates the difference between supplementation and substitution. These studies were conducted with cows grazing dormant native winter range forage. It is often common practice in winter range areas to supplement the dormant grass with corn. These trials were designed to evaluate the practice's effectiveness. Based on how much corn was fed, clearly substitution was taking place. The corn merely replaced the forage in these diets and met no dietary deficiency.

Substituting corn for range grass during the winter proved nonbeneficial. The levels fed were sufficient to change the rumen microbial population to one favoring starchy carbohydrate digestion, while reducing the microorganisms that digest the low-quality fiber present in the range forage. The result was a decreased digestibility of the grazed native range forage.

The cattle grazing only range forage performed better than those receiving 8.5 pounds of corn plus the range forage. The most limiting nutrient in the range forage diet was protein. This deficiency is not addressed by feeding a high carbohydrate feed such as grain.

Table 1. Results of feeding corn to cattle grazing native winter range.

Supplement	Frequency of feeding	Winter gain (lbs.)	Pregnancy rate (%)
Trial 1.			
3.5 pounds ear corn	daily	-121	***
3.0 pounds shelled corn plus 1 pound of 40% crude protein supplement	daily	- 40	***
Trial 2.			
6.5 pounds grain (9.4% crude protein)	twice weekly	- 5	68
1.8 pounds grain (9.4% crude protein)	daily	23	94
Trial 3. (Following calving)			
8.5 pounds corn (after calving)	daily	***	78
Native range only	***	***	94

Table 2 illustrates the effect on winter weight gains of 600-pound yearling heifers, resulting from varying the frequency of feeding protein supplements (cake).

Table 3 illustrates the effects of frequency of supplementation feeding on percent calf crop and calf weaning weights (supplement - 21 pounds of cottonseed cake per head weekly).

These results demonstrate that the feeding frequency of supplements to correct a protein deficiency can be effectively manipulated to fit various management practices and labor availability. Some benefit may actually accrue with less frequent feeding because rather than wait on daily delivery, the cattle move out and graze a more extensive area. Feeding larger amounts less frequently also allows timid cattle to consume their share. During calving, however, cows may need to be fed supplements daily, as their nutrient demands are much higher.

Protein supplementation also stimulates intake and digestibility of low-quality forage. Feeding protein supplements to cows grazing on native winter range is a more effective practice than feeding similar cows grain.

Other trials have shown that when all or a substantial part of the daily ration consists of harvested hay, with a moderate protein content (7 percent or higher), the addition of corn or other grain (energy supplement) to the ration may be beneficial. However, the level of grain fed should not exceed 0.25 percent of the cow's body weight or 2.5 pounds for a 1,000-pound cow. In this case, the grain becomes a supplement, as it is allowing an excess of protein in the ration to balance the energy in the grain. Graph 1 illustrates these important dietary concepts.

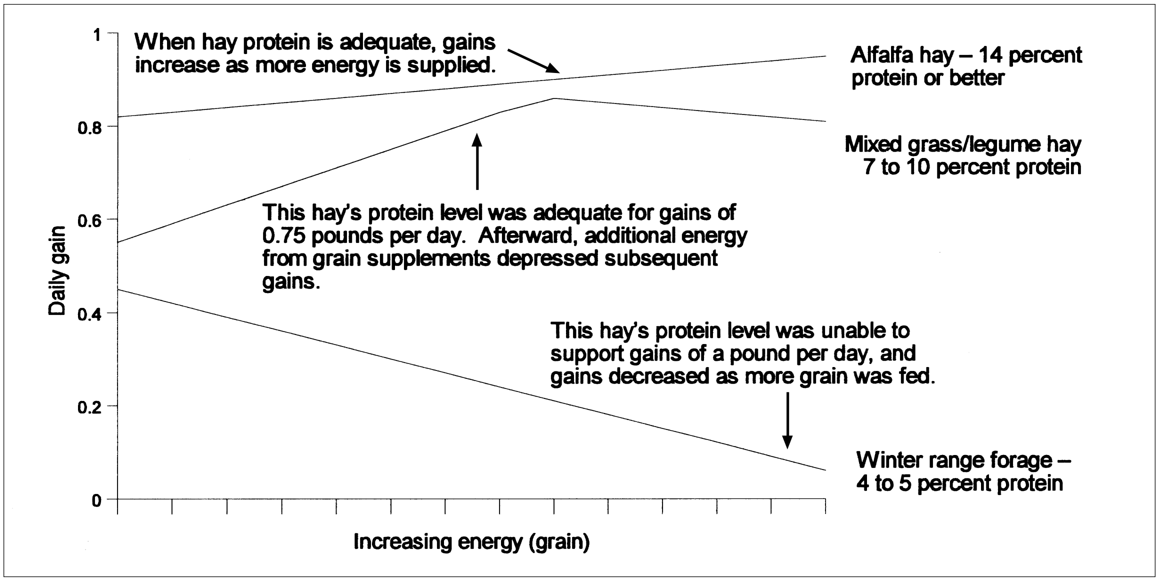
Table 2. Weight gains of yearling heifers, as affected by frequency of feeding protein supplementation during the wintering period.

Supplement type	Amount and frequency	Pounds gained
40 percent cake	1 pound daily	79
40 percent cake	7 pounds weekly	79
Alfalfa hay	4 pounds daily	97
Alfalfa hay	28 pounds weekly	78

Table 3. Effect of frequency of protein supplementation on production.

Amount and frequency of supplementation*	Calves weaned (percent)	Calf weaning weight (pounds)
3 pounds daily	81	445
7 pounds, 3 times weekly	86	437
10.5 pounds, 2 times weekly	89	450

*21 pounds of cottonseed cake fed per week per cow



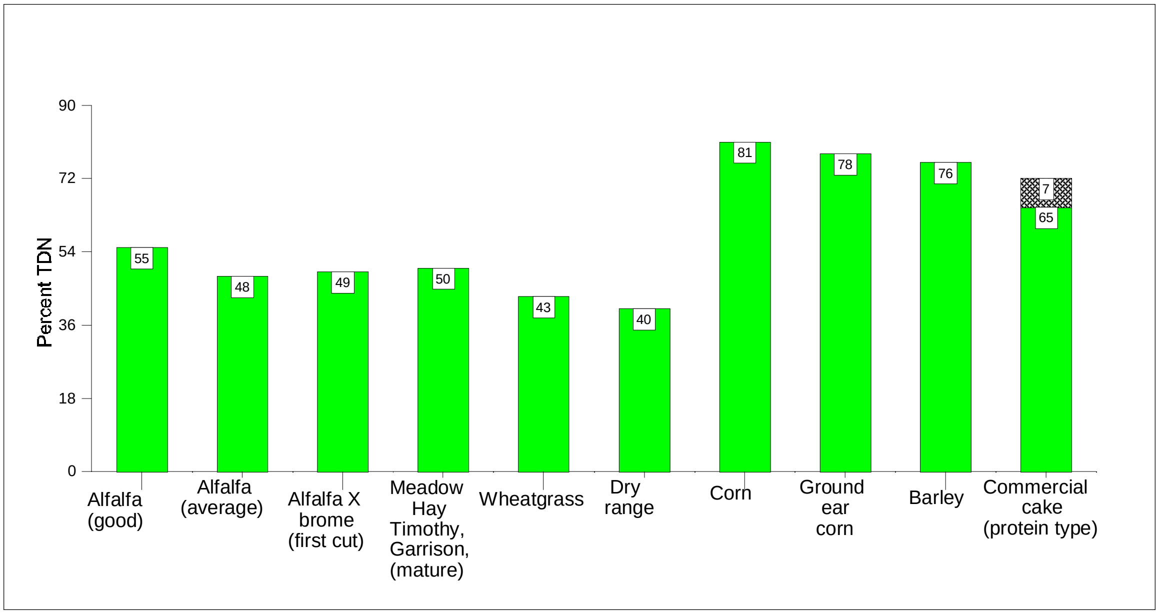
Graph 1. Effect on cattle gains when level of dietary protein varies.

Relative Value of Feeds for Supplementation

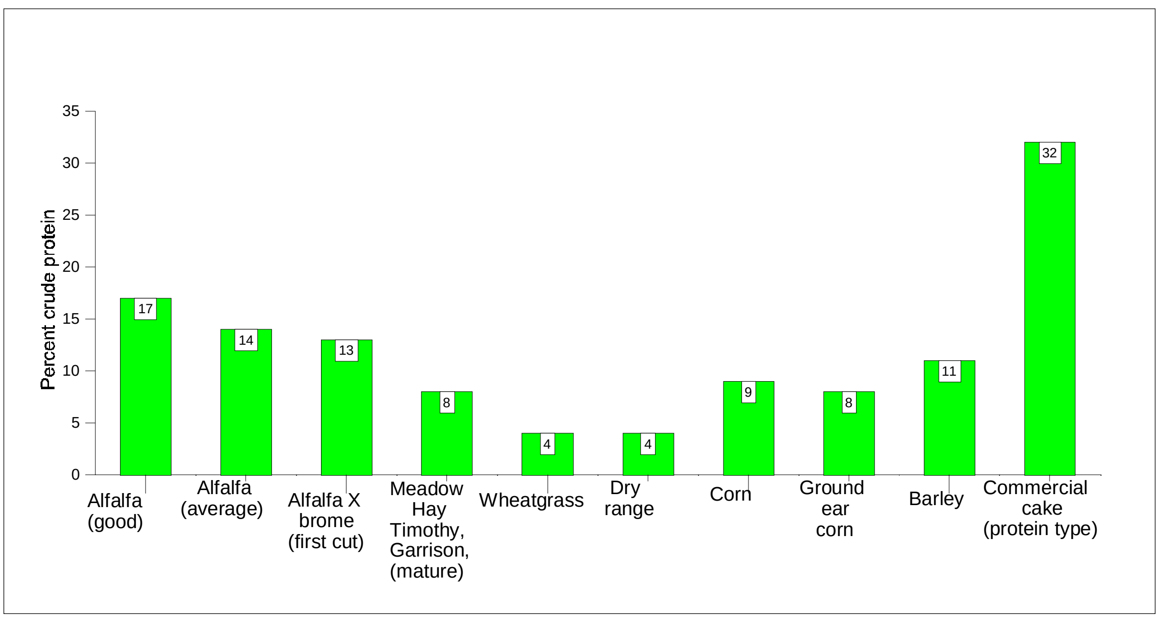
Graph 2 presents the relative total digestible nutrient (TDN) content of various feeds. TDN is an estimate of a feed's energy value and includes carbohydrates, fat, and protein. Graph 3 shows the relative crude protein (CP) concentration of the same feeds on an "as fed" basis. Although minerals and vitamins are important or even critical to animal performance in some situations, energy and/or protein is most likely needed in the greatest concentration in a supplementation program to balance a specific ration deficiency.

The values shown in Graphs 2 and 3, taken from the National Research Council's publication *Nutrient Requirements of Beef Cattle,* average several samples. Local adjustment has been made where appropriate. Note that in Graph 2, a variation occurs in the energy value of the commercial supplement (cake). Although the protein content, in this case 32 percent, is guaranteed on the feed tag, no guarantee is made for the energy value. This happens because the carrier used in the supplement may range from poor-quality forage to high-quality grains. To determine the supplement's approximate energy value, check the ingredient list. The ingredients shown on the tag generally are listed in descending order of their percent concentration in the supplement, but this may change depending upon their availability and cost. Feed tag listings are controlled by state laws, and the nutrient

Grass hay without protein supplementation will support only limited cattle weight gains. See Graph 1.



Graph 2. Relative energy (TDN) values found in commonly fed feeds (air dry basis or as-fed).



Graph 3. Relative crude protein values found in commonly fed feeds (air dry basis or as-fed).

percentages listed on the guaranteed analysis must be equal to or greater than the nutrient percentages contained in the feeds.

A wide range of commercially prepared feeds is available. Many feed mills make supplements ranging from 10 to 40 percent crude protein and higher. Some supplements are marketed as high energy when in reality they are actually low-protein products. Good-quality alfalfa may contain 16 percent or more crude protein and may be a less expensive supplementation method than a commercially prepared product, depending upon what nutrient is being supplemented.

Tag 1.

12% ENERGY CAKE
Feed Company, USA

GUARANTEED ANALYSIS

CRUDE PROTEIN, min..............12.0%
CRUDE FAT, min.........................3.0%
CRUDE FIBER, max.....................8.0%
CALCIUM (Ca), min.....................2.0%
CALCIUM (Ca), max....................3.0%
PHOSPHORUS (P), min...............0.7%
SALT (NaCl), min........................1.0%
SALT (NaCl), max.......................2.0%
VITAMIN A, min............20,000 IU/lb
VITAMIN D, min...............2,000 IU/lb

INGREDIENTS

Grain products, processed grain by-products, plant protein products, cane molasses, calcium carbonate, monocalcium phosphate, dicalcium-phosphate, salt, bentonite, vitamin A acetate, D-activated animal sterol (source of vitamin D3), iron sulfate, copper sulfate, cobalt carbonate, zinc oxide, manganous oxide, ethylenediamine dihydriodide, sodium selenite.

See back of tag for feeding directions.
Net weight shown on bag or bulk invoice.

Tag 2.

32% RANGELAND CAKE
Feed Company, USA

GUARANTEED ANALYSIS

CRUDE PROTEIN, min.................32.0%
CRUDE FAT, min..........................1.0%
CRUDE FIBER, max.....................12.0%
CALCIUM (Ca), min 2.0%
CALCIUM (Ca), max 3.0%
PHOSPHORUS (P), min 1.1%
SALT (NaC1), min 1.0%
SALT (NaC1), max 2.0%
VITAMIN A., min ....40,000 IU/lb
VITAMIN D., min ....4,000 IU/lb

INGREDIENTS

Plant protein products, processed grain by-products, grain products, cane molasses, calcium carbonate, monocalcium phosphate, diacalcium phosphate, salt, bentonite, vitamin A acetate, D-activated animal sterol (source of vitamin D3), iron sulfate, copper sulfate, cobalt carbonate, zinc oxide, manganous oxide, ethylenediamine dihydriodide, sodium selenite.

Alfalfa hay may be a better choice for a protein supplement than concentrate pellets or cubes.

Selecting Supplements

Supplements can be valued in several ways. The cost per ton is seldom an accurate indicator of the actual feeding value received. The cost per pound of actual nutrient provided by the supplement is a better method of pricing. However, convenience, storage, and other management aspects also are considerations that must be evaluated when purchasing a supplement. When a protein supplement is needed and various options are available, determine the cost per pound of actual crude protein provided in each supplement by using this formula: cost per ton ÷ (20 x CP percent) = the cost per pound of protein in the supplement.

1. *Alfalfa hay at $85 per ton and contains 16 percent CP*
   $85÷(20 x 0.16) = $0.265 (26.5¢) per pound of crude protein
2. *Commercial cake at 32 percent CP at $230 per ton*
   $230÷(20 x .32) = $0.36 (36¢) per pound of crude protein
3. *Cottonseed meal at 42 percent CP at $320 per ton*
   $320÷(20 x .42) = $0.38 (38¢) per pound of crude protein

In this case, alfalfa hay appears to provide the most economical source of protein. If some energy also is needed in the ration, it may be necessary to make the same calculations for the energy value of the three feeds in question. Balance this with the protein value to arrive at a final decision.

Table 4 presents several examples of how nutritional value of different feeds can be compared.

To evaluate feeds on their combined protein and energy values, it is convenient if a common base value can be selected against which other feeds can be compared. Alfalfa was selected as the principal feed (Table 4). Based on an air-dry feed condition, or an as fed state, the alfalfa, harvested at the mid-bloom stage of maturity, contains 15.5 percent crude protein and 50 percent TDN (energy). The cost per ton for this hay is $85 delivered to the ranch. Now, other feeds may be compared, on a nutrient and cost per ton basis, to this alfalfa hay.

Actual costs per ton will vary according to the hay market and demand versus availability. As an example of comparing costs of supplementation, assume that a 450-pound heifer is expected to gain 1 pound per day on a ration of 12 pounds of timothy hay with 7.5 percent protein and 50 percent TDN (energy). The requirements call for 1.06 pounds protein per day. The ration supplies 12 X .075 or 0.9 pounds protein. The amount of supplement required to

Table 4. Combined values for selected feeds.

Feed	Nutrition and value of mid-bloom alfalfa		Combined nutrition and value, %	Values per ton of feed compared with mid-bloom alfalfa
	Protein, %	TDN, %		
Mid-bloom alfalfa	100	100	100	$85
Late-cut alfalfa	93	96	94	$80
Early-cut alfalfa	107	102	104	$88
Mature crested wheatgrass	29	60	44	$37
Alfalfa X grass mix	87	98	92	$78
Oat hay	52	107	79	$67
Mid-bloom sweet clover	90	100	95	$81
Early-cut brome grass hay	90	100	95	$81
Early-cut meadow hay	53	94	73	$62

Table 5. Correcting a protein deficiency in the Timothy hay ration.

Protein supplement	Increase made per pound over Timothy hay	Pounds needed	Cost per pound	Total cost
Alfalfa hay @ 15.5%	.08	2	$.265	$.53
Commercial mix 32%	.24	.67	$.36	$.24
Cottonseed meal 42%	.34	.47	$.38	$.18

Note that as the protein level in a supplement increases, the cost per pound decreases, although the cost per ton is much different. This is just one way to look at the cost of supplementation.

meet this deficiency is calculated by increase needed divided by increase made. Using alfalfa hay as an example, the increase made per pound of hay is .155 – .075, or .08 pound increase (see Feed Composition Tables). The increase needed is 1.06 – .9 = .16 pound protein. So, .16 ÷ .08 = 2 pounds alfalfa.

Proof:

10 pounds Timothy @ .075	=	.75 pounds
2 pounds Alfalfa @ .155	=	.31 pounds
		1.06 pounds protein

The TDN supplied by this ration to meet 1 pound daily gain is marginal. Table 5 shows amounts needed to meet protein requirements based on four supplements.

When protein is being supplemented, those feeds with the highest percent CP may be the cheapest. However, alfalfa also provides additional energy and other benefits. The arithmetic used here gives a ball park estimate but illustrates that, before a supplement is selected, nutritional value, feeding ease, and availability must be considered.

Feed Composition and Feed Analysis

Table 6 shows the percent CP and TDN contained in some selected feeds. These values represent averages taken from many samples. When samples of homegrown feeds are collected and submitted to a laboratory for analysis, the values can be substituted for these book values. Several samples must be taken from the entire feed resource (i.e., hay pile) and then combined to achieve any degree of certainty. Differences can exist between different samples obtained from a single bale of hay.

An alternative to feeding expensive supplements during an animal's nutritional critical periods, such as late pregnancy or early lactation, is to postpone calving until the needed nutrients are available at a lower cost in actively growing spring/summer range forage (see Table 6 for nutritional values of growing forage).

Nonprotein Nitrogen

Urea, biuret, ammonia, and ammoniated products are examples of materials referred to as nonprotein (NPN) compounds. They supply elemental nitrogen to rumen microflora, upon ruminal digestion. This type of elemental nitrogen is the preferred source of nitrogen for many of the rumen microbes for cell growth and production. The rumen microflora combine this nitrogen with a soluble carbohydrate to form microbial protein in the form of microbial body cells. NPN compounds must be fed with a source of very soluble carbohydrate such as grain or molasses. The carbohydrate material binds with the NPN nitrogen and holds it in the rumen until the rumen microflora (bugs) can convert it into microbial cells. If adequate soluble carbohydrates are unavailable in the rumen, the NPN nitrogen is absorbed across the rumen wall, picked up by the blood, and excreted by the kidneys. In cases where animals consume large amounts of NPN nitrogen or when the absorbed blood levels of NPN nitrogen exceed the kidneys' ability to remove it, toxicity can result. NPN products are cheap when compared with natural proteins (plant or animal protein). Therefore, NPN compounds are frequently included in protein supplements in an attempt to reduce the cost of the supplement; sometimes it works and sometimes it does not. If an adequate level of soluble carbohydrate is not present in the rumen when this NPN supplement is consumed, up to one-third

Table 6. Feed Composition Tables.

Feed		Assume 90 percent dry matter as fed basis	
		CP percent	TDN percent
		Forages	
Alfalfa	– early bloom	16.5	51.3
	– mid-bloom	15.4	50.0
	– full-bloom	14.3	48.0
Brome grass hay	– early bloom	14.0	52.0
	– mature	6.0	53.0
	– early growing	21.0	74.0
Alfalfa brome mix – first cut		13.5	49.0
Meadow hay (mixed) – early cut		8.3	47.0
Oat hay with some grain		8.1	53.6
Mid-bloom sweet clover hay		14.0	50.0
Mid-bloom timothy		7.5	50.0
Full-bloom crested wheat grass		4.5	30.0
Mature native range		4.1	43.0
Kentucky bluegrass – early, fresh		17.4	72.0
Native range grasses – early, fresh		9.0-11.0	64.0-74.0
		Grains and other low protein concentrates	
Barley, grain		11.6	74.0
Corn grain #2		8.9	81.0
Ground ear corn		8.1	78.0
Oats, grain		11.9	68.0
Wheat, grain		12.7	78.0
Three-way mix (corn, oats, and barley)		9.0	72.0
70 x 30 pellet (alfalfa, corn)		13.2	57.0
80 x 20 cube (alfalfa, corn)		14.1	56.0
		High-protein supplements	
Cottonseed meal (solvent extract)		42.0	73.0
Soybean meal (solvent extract)		46.0	72.0
Commercial mix (20 percent)		20.0	66.0
Commercial mix (32 percent)		32.0	64.0
Commercial mix (50 percent)		55.0	64.0

Note: The TDN values of commercial mixes vary according to the base feeds and other materials used.

or more of the NPN nitrogen (protein equivalence) can be lost to the animal via NPN nitrogen excretion in the urine. This problem is common when NPN containing supplements are fed to ruminant animals maintained on forage diets. The amount of NPN included in the supplement must be listed in the ingredient portion of the feed tag. NPN containing supplements will kill non-ruminant animals, such as horses, so as these feeds are used, extreme care must be employed to ensure that only the ruminants receive the NPN feed. For instance, Tag 3 for a 32-percent CP supplement contains 9 percent equivalent protein from NPN, which equals 28 percent of the total protein or 3.2 pounds of urea per 100 pounds of supplement. Liquid supplements made with molasses may contain up to 99 percent of their protein equivalent from NPN sources.

How efficiently the NPN is converted to microbial protein in the rumen depends upon several factors. The amount of energy

Tag 3.

32% WESTERN CAKE
Feed Company USA

GUARANTEED ANALYSIS

CRUDE PROTEIN, min.................	.32.0%
*This includes not more than 9% equivalent protein from non-protein nitrogen.	
CRUDE FAT, min.........................	1.0%
CRUDE FIBER, max....................	12.0%
CALCIUM (Ca), min	2.0%
CALCIUM (Ca), max	3.0%
PHOSPHORUS (P), min	1.1%
SALT (NaCl), min	1.0%
SALT (NaCl), max.........................	2.0%
VITAMIN A, min.................	40,000 IU/lb
VITAMIN D, min.................	4,000 IU/lb

INGREDIENTS

Plant protein products, processed grain by-products, grain products, urea, cane molasses, calcium carbonate, monocalcium phosphate, diacalcium phosphate, salt, bentonite, vitamin A acetate, D-activated animal sterol (source of vitamin D3), Iron sulfate, copper sulfate, cobalt carbonate, zinc oxide, manganous oxide, ethylenediamine dihydriodide, sodium selenite.

See back of tag for feeding directions.

Net weight shown on bag or bulk invoice.

Table 7. Guides for NPN use.

	Percent use	
Ration type	Dry supplement	Liquid supplement
Weathered grass Crop residues Poor-quality hay	0 to 25	50
Medium-quality hay Silages Summer pasture	40 to 60	80
High-energy rations	90 to100	90 to 10

WARNING
.13-.23 gram urea per body weight pounds = toxicity
.45-.68 gram urea per body weight pounds = lethal/death

the ration contains and the quality of the roughage consumed are primary factors. NPN may perform as well as natural proteins in rations high in grains, such as feedlot finishing diets, but very poorly in high-roughage winter diets. Efficient NPN conversion depends upon microbial fermentation rates in the rumen and the availability of soluble carbohydrates. Grains are a highly fermentable, soluble carbohydrate source, while roughages ferment slowly and provide little soluble carbohydrate. Urea, an NPN product, is highly toxic. The danger of urea poisoning is present when it is placed in rations that do not ferment quickly.

Guidelines for NPN Use

The table on page 47 demonstrates the percent of nonprotein nitrogen (NPN) that can be used with various feed types. Ruminant animals on range grass or poor-quality hay use from 0 to 25 percent of the NPN included in a dry supplement or up to 50 percent of that present in a liquid supplement. (This is due to the molasses base providing a soluble carbohydrate in the liquid supplement.)

The table below shows another method of estimating NPN use based on the protein content of the base feeds and indicates there is a maximum limit.

Table 8. Upper limit for NPN use.

Percent CP in DM before NPN	Percent TDN in ration dry matter					
	55 to 60	60 to 65	65 to 70	70 to 75	75 to 80	80 to 85
	(Percent CP after NPN addition)					
8	No	10.0	10.5	10.9	11.2	11.4
9	No	10.4	10.9	11.3	11.6	11.8
10	No	10.8	11.3	11.7	12.0	12.2
11	No	11.2	11.7	12.1	12.4	12.6
12	No	No	12.1	12.5	12.8	13.0

Chapter 6

Environmental Effects on Feed Intake and Production

Feed intake in beef cattle is affected by temperature, precipitation, wind, mud, and other factors. Animal acclimatization or susceptibility to stress also are factors that may influence intake. The duration of adverse conditions is important to know to determine at which point more serious effects on animal condition and performance will occur.

Temperature

The thermal environment is among the important factors in cattle performance. Generally, as temperatures decline, the cattle's energy flow is affected. The thermoneutral zone (TNZ) is the temperature range in which animals experience maximum performance with minimal nutritional supplements and no thermal stress. As the temperature drops below the lower end of TNZ of the animals, they become cold and must expend energy to maintain body temperature, referred to as the lower critical temperature (see Tables 1 and 2). Windchill, precipitation, and other factors influence the actual effective temperature. These elements are interactive, so separating their individual influences is impossible. However, if only temperature and windchill are being considered, a useful guide to estimate temperatures has been developed (see Table 3).

Table 1. Estimated lower critical temperatures for beef cattle.

Coat description	Temperature (Lower critical temperature)
Summer coat or wet	59 degrees Fahrenheit
Fall coat	42 degrees Fahrenheit
Winter coat	32 degrees Fahrenheit
Heavy winter	18 degrees Fahrenheit

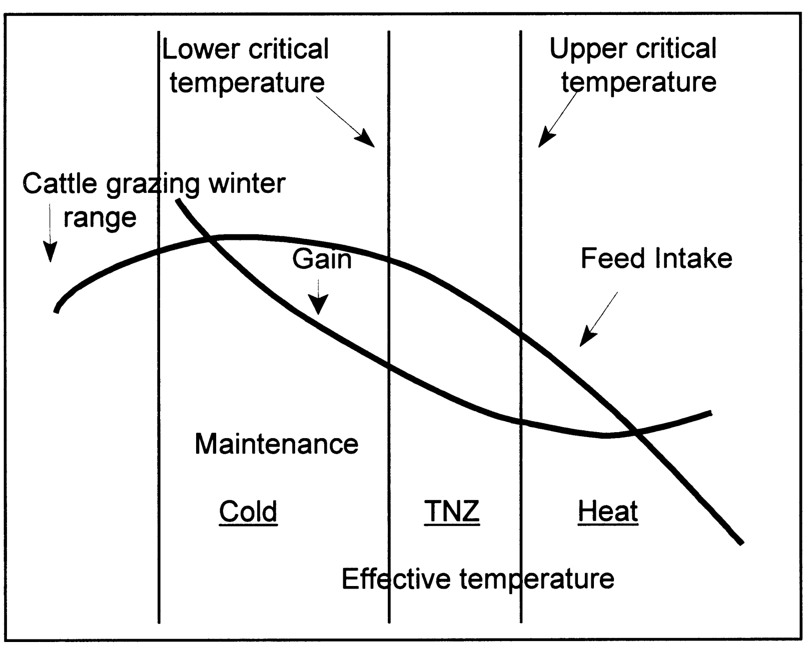


Table 2. Temperature effects on feed intake rate, maintenance energy requirement, and energy retained as product (gain).

Table 3. Effective environmental temperatures for cattle with winter hair coats and exposed to winds of different velocities.

Wind speed (mph)	Temperature (degrees Fahrenheit) -10	-5	0	5	10	15	20	25
Calm	-10	-5	0	5	10	15	20	25
5	-16	-11	-6	-1	3	8	13	18
10	-21	-16	-11	-6	-1	3	8	13
15	-25	-20	-15	-10	-5	0	4	9
20	-30	-25	-20	-15	-10	5	0	4
25	-37	-32	-27	-22	-17	-12	-7	-2
30	-46	-41	-36	-31	-27	-21	-16	-11

If other environmental factors do not influence animals, the windchill factor can be considered the effective environmental temperature. To reach the lower critical temperature of approximately 18 degrees Fahrenheit (cows with heavy winter coats), the ambient temperature should be 25 degrees Fahrenheit with a wind speed of 5 miles per hour.

Adjusting Rations for Cold Stress

The major effect of cold is an increased energy requirement. Cattle in good condition may meet their increased energy demands for short periods, but prolonged cold (three to four days) requires that energy available to the body be adjusted, either by breaking down muscle tissue or by increasing supplemental energy in the diet. Cattle prepare for this additional, predictable energy drain during cold weather by increasing rumen mobility and the rate at which material moves through the digestive tract. Increase feed (energy), such as TDN 1 percent, for each degree the temperature drops below the lower critical temperature (LCT). For example, the LCT for cows with heavy winter coats is 18 degrees Fahrenheit. If the effective temperature is 6 degrees Fahrenheit, there is a 12-degree difference; therefore, a TDN increase of 12 percent is called for. Assuming cows weigh 1,000 pounds and are consuming 20 pounds of (45 percent TDN) grass hay, the ration's energy needs to be increased 12 percent, which equals 2.16 pounds of additional hay or 22.16 pounds of hay daily (see Table 4).

Little evidence supports the concept that other nutrients, such as protein, minerals, and vitamins, are affected by cold stress to the extent that energy is.

This windbreak structure located at Miracle Mile in Carbon County, Wyoming, provides protection from cold winds, raising the effective temperature of cattle behind the windbreak.

Effect of Cold Temperatures on Grazing Behavior

Cattle grazing winter range forage as their sole source of nutrients exhibit behavior different from cattle wintered on average- to high-quality harvested forage. A positive correlation exists between ambient temperature and grazing time. As the temperature drops, less time is spent grazing, which results in a corresponding decrease in total forage intake. Animals then experience increased stress due to a dietary energy deficiency. Table 5 shows the relationship between effective temperature (ambient temperature plus windchill) and hours spent grazing.

Table 6 illustrates how the energy deficiency may increase as the effective tem-

Table 4. Roughage capacity of beef cows (900 to 1,100 pounds).

Roughage type	Class of cattle	Dry matter capacity percent of body weight	As fed capacity pounds
Low-quality roughage	dry cows	1.5	17-18
(dry grass, straw, etc.)	wet cows	2.0	23-24
Average-quality hays	dry cows	2.0	22-24
(meadow, native, etc.)	wet cows	2.3	25-28
High-quality forages	dry cows	2.5	28-30
Alfalfa hay	wet cows	2.7	30-32

Table 5. Daily grazing time of cows at various air temperatures and wind velocities.

Average daily wind velocity (miles per hour)	Minimum daily air temperature degrees Fahrenheit				
	40	20	0	-20	-40
	Grazing time (hour per day)				
0	9.8	8.4	7.1	5.7	4.3
10	9.1	7.7	6.4	5.0	3.6
20	8.4	7.0	5.7	4.3	2.9

Table 6. Intake and digestibility of grazed range forage during the winter.

Intake pounds per day	Intake pounds per 100 pounds of body weight	Digestibility percent	Temperature degrees Fahrenheit
25.5	2.3	55.4	5
26.2	2.4	59.6	4
20.9	1.9	55.9	10
19.1	1.7	52.5	-22
15.0	1.3	38.2	-17
19.1	1.7	43.0	32
16.9	1.5	36.5	15

Cold temperatures affect cattle behavior and production.

peratures decrease and grazed forage intake and digestibility decline.

The grazing activity is a major energy expenditure for range cattle. Energy requirements for grazing may be 40 percent greater than for similar confined cattle. Several variables are involved in this increase—the availability of natural windbreaks and sheltered bedding areas, forage location, quality and availability, topography of the grazed area, and distance to water.

Attempting to supplement energy deficiencies of poor-quality, mature range forage (3 to 8 percent protein and 28 to 40 percent TDN) with grain or other low-protein supplements is generally ineffective and can be detrimental to animals. In this case, the rumen microbial population is altered, as a result of adding grain to the diet, from a population of microflora that digest fiber to one in which the microorganisms digest grain. The result is reduced fiber digestion, which increases the dietary energy deficiency of the animal, as well as decreasing the animal's ability to keep warm during cold weather. During digestion, energy is liberated every time a carbon bond is broken. Forage has more carbon bonds to break than grain; therefore, supplementation during very cold periods is more effective if higher quality forages, such as alfalfa, are fed rather than grains.

Seasonal Effect on Intake

Season or day length effects on feed intake are less understood than temperature stress. Certain studies have indicated that dry matter intake (forage adjusted to zero water content) increased 0.32 percent per hour as day length increased. Considering the change from an arbitrary 12 hours of light per day, voluntary intake would be 1.5 to 2.0 percent greater in July and 1.5 to 2.0 percent lower in January in the northern hemisphere. As with weather stress, other factors such as forage availability and quality, production in pounds per acre, grazing management, and animal production status will influence daily feed intake.

Effect of Heat

Not only heat, but accompanying humidity, leads to daytime heat stress. A 1995 heat wave in the central United States cost the cattle industry $28 million in deaths and performance loss. Using a temperature humidity index (THI), scientists have found strong links between animal losses and three or more successive 24-hour periods with daytime THI scores of more than 83 and nighttime scores of 74. Reducing total ration amounts, changing ration types (more grain and less forage), or changing feeding times during periods of high THI are alternatives that might be considered.

In high desert areas, such as western Wyoming, reaching a critical THI may be a moot point.

Chapter 7

Marketing Cattle

An important dilemma cattle producers face is how to market cattle for optimal return investments. The market is fickle, and predicting what turn it might take is difficult because several factors affect prices. An example of the effect corn prices have on cattle prices is shown in Figure 1.

The market is affected by both long-term and seasonal cycles or patterns. The most easily recognized long-term influence is the cattle cycle, which reflects inventory and, inversely, the price received by producers.

However, seasonal patterns also affect prices, and the highs and lows are fairly predictable during a twelve-month period. These seasonal patterns are related to cattle availability and marketing trends.

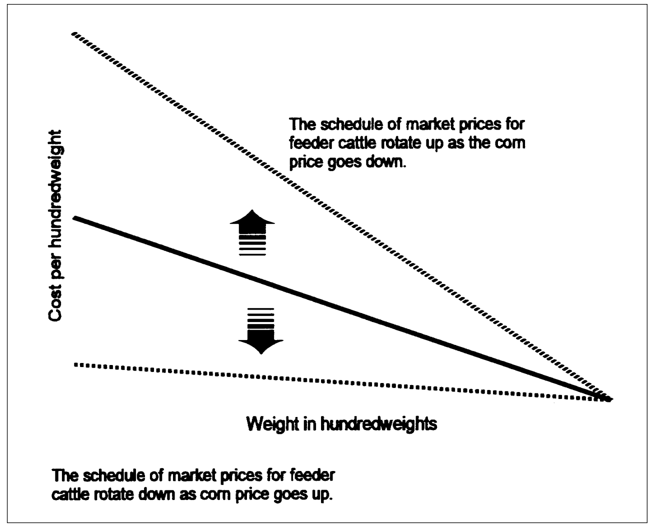


Figure 1. Impact corn price has on the price of feeder cattle.

The Cattle Cycle

Historically, the full cattle cycle has been approximately 10 years, with inventories of cattle on farms and ranches increasing for six years and decreasing for approximately four years. However, variations have been observed, such as the liquidation during the 1980s, that lasted eight years.

Producers expand inventories in response to profits and then liquidate in response to losses or prices near the break-even point. Calf marketing falls behind the increase in herd numbers, as it takes about two to three years to get a cow into production. High numbers will lag three to five years behind the price peak.

Figure 3 shows the cattle cycle from 1930 projected to 1999. The trend from 1930 was for each succeeding peak to be higher than the preceding one until the 1979 to 1990 cycle when a record high was never established.

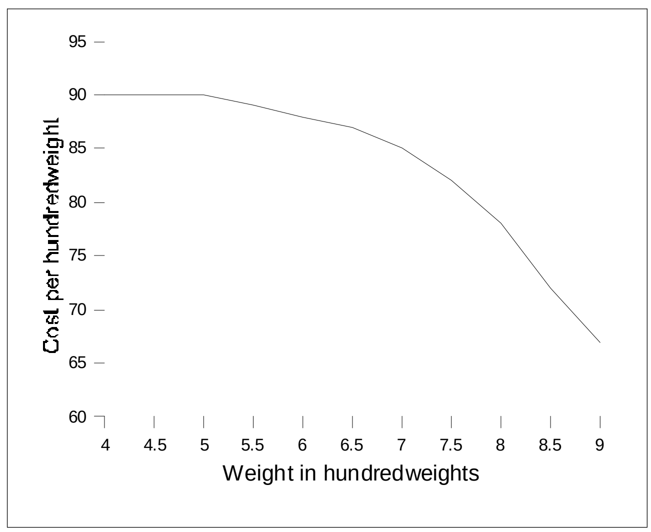


Figure 2. Steer weight relationship to price per hundredweight pounds.

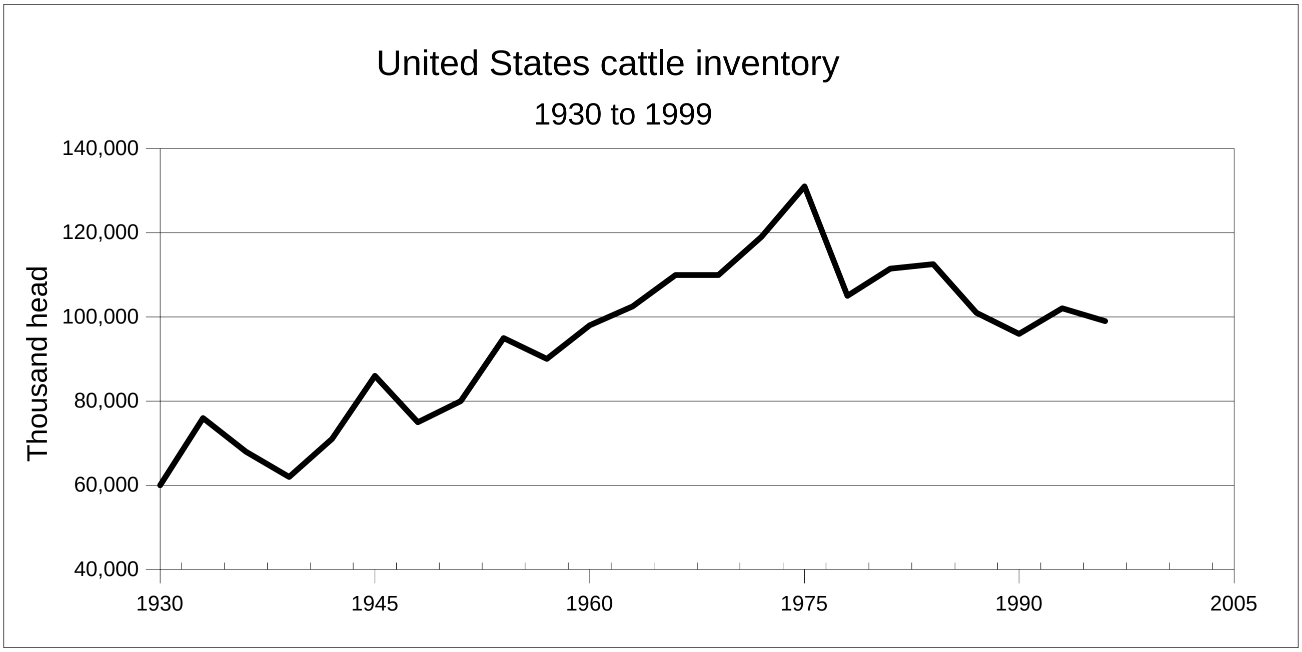


Figure 3.

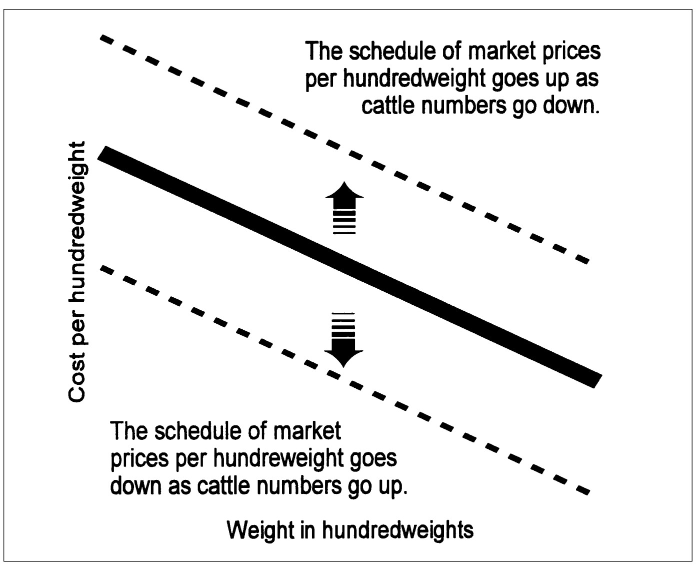


Figure 4. Impact of feeder cattle supplies on the market price.

The profitable period in the cycle will increase its length before significant liquidation occurs. When producers have had more profit, it takes longer for the money to run out. A current factor that lengthens the cycle is the dramatic increase in beef exports, which play a minor role in supporting prices.

Seasonal Price Changes

The seasonal variation in prices received for slaughter cows (culls) and feeder cattle is predictable and useful when making annual marketing decisions (see Figure 5). Cull cow prices are lowest in November, the traditional time spring-born calves are weaned and cull cows are sent to market. The cost of wintering these cows and selling them in February or March may offer producers an option to increase net returns.

As weights increase, the price of feeder cattle declines. However, Figure 6 illustrates how the price of feeder steers steadily declines in the fall when market numbers are large. The prices begin to recover in the spring when cattle availability is less, reaching a peak when grass cattle demand is highest.

Marketing Strategies

Producers have several options when selling cattle. However, the objective is clear—sell at the highest competitive price while holding marketing costs to a minimum.

Traditional techniques have long been established and continue to be valid when they serve the needs of producers. These include:

- Auction yards – Torrington and Riverton, Wyoming; Fort Collins, Colorado; and Billings, Montana
- Private treaty transactions (forward contracts for fall delivery at agreed upon price and weight)
- Order buyers and country dealers

Due to the cost of maintaining buyers and the various livestock available at local auctions, competition for cattle has declined while the associated marketing costs to the seller have risen. As a result, several innovative marketing methods have been introduced.

Pooling

Grouping cattle from several producers to sell them in larger lots is more attractive to buyers. However, attempts to sell cattle this way have failed due to a lack of confidence by both sellers and buyers concerning grading methods and subsequent sorting into uniform lots. Also, pooling specifications have not been adhered to by some consigners who felt their cattle were superior and worth more money than others. Lessons learned from earlier attempts have been implemented in successful pools. Feedlot operators prefer lots of 100 to 250 cattle grouped by sex, weight, and breed. A pool may assemble several lots from among the cattle consigned to the pool. Because of the costs and time spent sorting and handling mixed cattle, those already sorted into desirable groupings should demand a higher price from buyers.

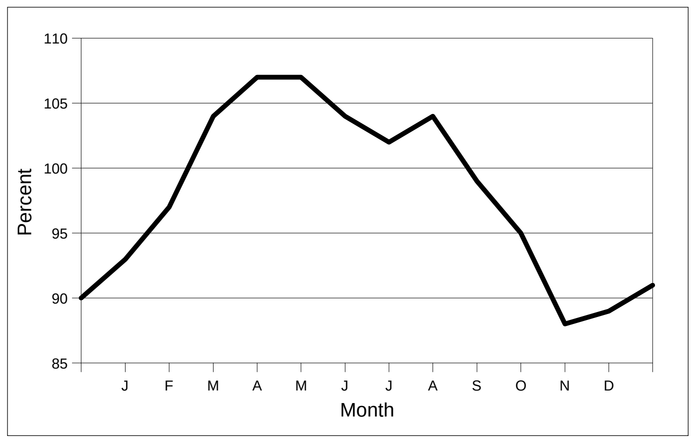


Figure 5. Slaughter cows' commercial monthly average price as a percentage of annual average price.

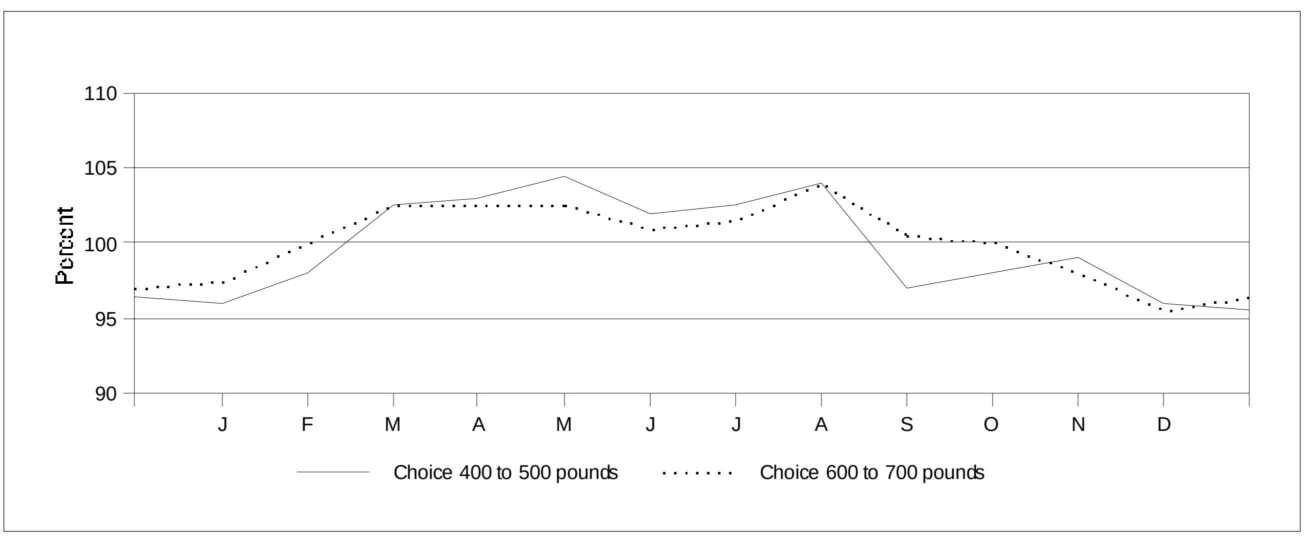


Figure 6. Feeder steers monthly average prices as a percentage of annual average price.

Video Auctions

A recent variation of the pooling method is video auctions. The auction company enforces the rules strictly.

This system operates in the following way:

- The auction company produces a two- to three-minute video tape showing a representative group of cattle from those that will be offered for sale. For example, costs for filming might be $3 per head sold, plus a $6 commission fee on the total sale. There is some refund on "no-sale."
- On sale day, the videos are broadcast via satellite to several geographical areas.
- Buyers are allowed to preview each lot, and bids are taken during the two- to three-minute showing. Buyers must register and are assigned a number. They may bid on site or by telephone.
- Ownership is transferred at a location selected by the seller based on conditions stated at sale time. These conditions include delivery dates, shrink, weighing conditions, and a health program.

Both the pooling method and video auctions may be combined when producers do not have enough cattle to make attractive lots.

Retained Ownership and Custom Feeding

With this approach, producers retain ownership through part or all of the finishing period. With increased availability of marketing information via computer agricultural networks, this method has become a popular marketing strategy.

Some advantages to retained ownership are:

- The producer can increase profits when above average performance in the feedlot is expected.
- The producer can manipulate the breeding program when feedlot performance and carcass data are available.

Some disadvantages include:

- Cash flow delay
- Increased financial risks such as changes in interest and taxes
- Loss of management control

Feed and Yardage Costs

Yardage covers operations and overhead costs to the feedlot, which may be charged separately from feed or added as a mark up. When comparing ration costs between custom feedlots, using feed on a dry matter basis is necessary, because feedlots often charge for water content in a seemingly cheaper ration.

Because of the risks involved in retaining ownership beyond weaning (death loss, veterinary costs, interest, and poor feedlot performance), it is imperative that a plan for risk management be implemented. This plan may include locking in the selling price by purchasing forward contracts, forming a partnership with the feedlot during the feeding period, or selling the cattle at some point during the feeding period. Calves that weigh 600 pounds or more at weaning are good candidates for a 100- to 150-day feeding period, while those weighing less may be backgrounded (low-energy growing ration) or run as stockers on pasture (see Table 1 for an example of a custom feeding worksheet).

Table 1. Cost and returns of custom feeding.		Cost per head	
		Example	Input
1	Cattle value at weaning (650 pounds at 80 cents)	$520	
2	Finished cattle value (1,200 pounds at 70 cents)	$840	
3	Feed, medicine, and yardage costs + interest on feed and yardage ($1.50 per day x 175 days)	$262.50	
4	Opportunity costs (cattle value placed in feed lot times 8 percent, ÷ 365 x 175 days) ($565.50 x.8) x (175 ÷ 365)	$19.95	
5	Death loss (2 percent) ($9 per head for each 1 percent)	$18	
6	Marketing and trucking costs ($1.50 check off and brand inspection, $10 trucking)	$11.30	
7	Total return 2 minus (1 + 3 + 4 + 5 + 6) $840 minus ($520 + $262.50 + $19.95 + $18 + $11.30)	$8.25	

Marketing Costs

The total cost of marketing can be high if transportation, shrink, and commissions are considered. The cost to both buyer and seller can be 8 to 10 percent of the cattle's value. For instance, the marketing costs on an 850-pound steer selling for 70 cents per pound would be 850 x .70 = $595 x .09% = $53.55.

Note: These comparisons are for 600- to 800- pound yearling feeder steers with adjustments made for transaction costs associated with the auction. Without adjustment, prices at regional markets are slightly higher than those for video markets (see Table 2).

Table 2. Cost comparison by method.

Auction	Major buyers attending	Price received per hundredweight (cwt) by video over a regional auction market	Commissions and deductions
Video	30	---	2 percent of sale + $1.50 per head
Oklahoma City, Oklahoma	15	$.95 per cwt	$7.34 per head
Greeley, Colorado	15	$3.36 per cwt	2 percent of sale + $1.50 per head
Dodge City, Kansas	20	$1.48 per cwt	$7.20 per head

Table 3. Selling cattle (Net prices after allowing for shrinkage–prices, per hundredweight).

Offer per hundred-weight	Percent shrink					Offer per hundred-weight	Percent shrink				
	2%	3%	4%	6%	8%		2%	3%	4%	6%	8%
$	$	$	$	$	$	$	$	$	$	$	$
90.00	88.20	87.30	86.40	84.60	82.80	57.00	55.86	55.29	54.72	53.58	52.44
89.00	87.22	86.33	85.44	83.66	81.88	56.00	54.88	54.32	53.76	52.64	51.52
88.00	86.24	854.36	84.48	82.72	80.98	55.00	53.90	53.35	52.80	51.70	50.60
87.00	85.26	84.39	83.52	81.78	80.04	54.00	52.92	52.38	51.84	50.76	49.68
86.00	84.28	83.42	82.56	80.84	79.12	53.00	51.94	51.41	50.88	49.82	48.76
85.00	83.30	82.45	81.60	79.90	78.20	52.00	50.96	50.44	49.92	48.88	47.84
84.00	82.32	81.48	80.64	78.96	77.28	51.00	49.98	49.47	48.96	47.94	46.92
83.00	81.34	80.51	79.68	78.02	76.36	50.00	49.00	48.50	48.00	47.00	46.00
82.00	80.36	79.4	78.72	77.08	75.44	49.00	48.02	47.53	47.04	46.06	45.08
81.00	79.38	78.57	77.76	76.24	74.52	48.00	47.04	46.56	46.08	45.12	44.16
80.00	78.40	77.60	76.80	75.20	73.60	47.00	46.06	45.59	45.12	44.18	43.24
79.00	77.42	76.63	75.84	74.26	62.68	46.00	45.08	44.62	44.16	43.24	42.32
78.00	76.44	75.66	74.88	73.32	71.76	45.00	44.10	43.65	43.20	42.30	41.40
77.00	75.46	74.69	73.92	72.38	70.84	44.00	43.12	42.68	42.24	41.36	40.48
76.00	74.48	73.72	72.96	71.44	69.92	43.00	42.14	41.71	41.28	40.42	39.56
75.00	73.50	72.75	72.00	70.50	69.00	42.00	41.16	40.74	40.32	39.48	38.64
74.00	72.52	71.78	71.04	69.56	68.08	41.00	40.18	39.77	39.36	38.54	37.72
73.00	71.54	70.81	70.08	68.62	67.16	40.00	39.20	38.80	38.40	37.60	36.80
72.00	70.56	69.84	69.12	67.68	66.24	39.00	38.22	37.83	37.44	36.66	35.88
71.00	69.58	68.87	68.16	66.74	65.32	38.00	37.24	36.86	36.48	35.72	34.96
70.00	68.60	67.90	67.20	65.80	64.40	37.00	36.26	35.89	35.52	34.78	34.04
69.00	67.62	66.93	66.24	64.86	63.48	36.00	35.28	34.92	34.56	33.84	33.12
68.00	66.64	65.96	65.28	63.92	62.56	35.00	34.30	33.95	33.60	32.90	32.20
67.00	65.66	64.99	64.32	62.98	61.64	34.00	33.32	32.98	32.64	31.96	31.28
66.00	64.68	64.02	63.36	62.04	60.72	33.00	32.34	32.01	31.68	31.02	30.36
65.00	63.70	63.05	62.40	61.10	59.80	32.00	31.36	31.04	30.72	30.08	29.44
64.00	62.72	62.08	61.44	60.16	58.88	31.00	30.38	30.07	29.76	29.14	28.52
63.00	61.74	61.11	60.48	59.22	57.96	30.00	29.40	29.10	28.80	28.20	27.60
62.00	60.76	60.14	59.52	58.28	57.04	29.00	28.42	28.13	27.84	27.26	26.68
61.00	59.78	59.17	58.56	57.34	56.12	28.00	27.44	27.16	26.88	26.32	25.76
60.00	58.80	58.20	57.60	56.40	55.20	27.00	26.44	26.19	25.92	25.38	24.84
59.00	57.82	57.23	56.64	55.46	54.28	26.00	25.48	25.22	24.96	24.44	23.92
58.00	56.84	56.26	55.68	54.52	53.36						

Shrinkage in Cattle

The price received per pound by the seller is affected by the cattle's actual scale weights. Several factors influence actual weights that fit into one major category referred to as shrink. For instance, if the buyer offers $75 per hundredweight (cwt.), and the cattle shrink 3 percent during standing and handling, the actual price received on an 850-pound steer is $72.75, a difference of $19.

Table 3 shows the net price received as opposed to the buyer's offer (or a range of offers) with shrinkages from 2 to 8 percent.

Three types of shrink are common. They are pencil, excretory shrink or loss of intestinal tract fill, and tissue shrink, which is an actual loss of body weight from the cells. Pencil shrink is deducted by the buyer at the time of delivery and is an arbitrary value agreed upon by both the buyer and the seller. Pencil shrink is subtracted from the scale weight of the cattle. Excretory shrink is urination and the loss of material from the intestinal tract. Excretory shrink is generally easy to recover once animals arrive at their final destination. Tissue shrink is actual weight loss from the body cells and is the most serious from a health standpoint and the most difficult to recover. The magnitude of tissue shrink is closely related to animals' mortality and morbidity when they reach their final destination. Both excretory and tissue shrink may occur simultaneously after an extended period of hauling or standing without food and water. Table 4 shows some estimated shrink losses, which are based on research.

Table 4. Shrinkage losses of cattle.

Conditions	Percent shrink
8 hour dry-lot stand	3.3
16 hour dry-lot stand	6.2
24 hour dry-lot stand	6.6
8 hours in truck transit	5.5
16 hours in truck transit	7.9
24 hours in truck transit	8.9

The greatest amount of shrink occurs during standing and hauling; this loss is intestinal tract fill, after which tissue loss begins. Excretory shrink, however, will vary according to the type of feed cattle have eaten. Cattle consuming grass or wet feed shrink approximately 4 percent after an overnight stand, while those on concentrates (grain) shrink approximately 2.5 to 3 percent. Range cattle shrink more than feedlot cattle because they are less accustomed to confinement. Stress and handling techniques (rough handling) can greatly increase shrink levels.

Cattle being hauled will shrink approximately .6 percent per 100 miles in transit. Cattle should not be overfilled before weighing and transit, because cattle buyers can easily detect this and may insist on a price discount or an arbitrary pencil shrink. Buyers are not going to pay 80 cents per pound for gut fill. Transportation regulations allow scale weights of 50,000 pounds of live animal weight. This equals approximately 70 head of 700-pound yearlings or 110 head of 450-pound calves.

Once cattle arrive at a destination and are returned to feed, considerable time elapses before original shipping weights are regained (see Table 5).

Table 5. Amount of time that passes before original shipping weights are regained.

Cattle type	Original weight pounds	Miles in transit	Percent shrink	Number of days to regain original weight
Yearling	675	660	9.2	16
Calves	500	660	9.5	13

Producers who make one or two shipments a year are at a disadvantage when bargaining with buyers whose livelihood depends upon being able to estimate shrinkage and make offers. Procedures may differ among buyers, sellers, and states and may include holding cattle overnight with an early morning weight and/or a pencil shrink from the actual scale weights.

Selling on the Slide

Using a price slide agreed upon between the seller and the buyer adds flexibility for both parties. Basically, it is a provision by which the delivery price is adjusted for differences in the estimated delivery weights due to weather conditions, forage quantity and quality, and unforseen factors. The seller and buyer only can estimate delivery weights when a contract is made well ahead of the shipping date, causing reluctance on the buyer's part to pay top dollar. Using the price slide increases the buyer's confidence when offering a bid. Buyers purchasing yearling cattle destined to go directly for finishing in a feedlot consider several factors when offering a bid, and the cost of feedlot gain is an important factor. The following excerpt is an example of how the slide might be employed in an actual contract situation.

Contract for sale made on April 1. Delivery to ranch on May 15 at 650 pounds. Estimated delivery weight and date is September 15 at 850 pounds with a 3 percent pencil shrink. (Approximately 875 pounds on scale minus 25 pounds of pencil shrink to compensate for feed and water or intestinal tract fill.) Price on delivery weights at $80 per cwt. or 80¢ per pound. A $4 per cwt. or 4¢ per pound slide if weights exceed 850 pounds shrunk, with a 10-pound window or grace over 850 pounds. Generally no slide is given if animals are lighter than the agreed upon weights.

On the delivery date, the shrunk weights averaged 880 pounds, or 30 pounds more than the contract agreement. The 10-pound grace allows the slide of $4 per hundredweight to apply to an extra 20 pounds. Therefore, implementing the slide reduces the $80 per hundredweight bid. (20 pounds x 0.04 = 0.80 per cwt.) The seller then receives $80 per hundredweight - 0.80 or $79.20 per 100 pounds for the cattle.

Slides differ according to conditions and agreements. The window above estimated weights may vary from 5 to 10 pounds. The increments may break at 15 to 25 pounds, rather than on a per pound basis; some slides may add $1 per hundredweight for additional weights, rather than penalize.

The added incentive for additional weight is based on what the buyer estimates his cost of gain will be in the feedlot. If the

Table 6. Price slides for cattle of various weights and classes.

Weight (pounds)	Price spread (slides)
400 to 525	$10/cwt
525 to 600	$7 to $8/cwt
600 to 675	$5/cwt
675 to 750	$4/cwt
750 +	$3 to $4/cwt
Steers	————
Heifers	$8 to $12/cwt less

cost of the grass gain is less than feedlot costs, he may offer incentive for the extra pounds.

Another concern is when cattle weigh less on delivery than expected. Buyers are reluctant to add a slide on the downside for fear the cattle may have been misrepresented. The seller must insist on some protection in case of drought or other factors.

Table 6 shows common price slides for various weight cattle. Risk to the buyer is an important factor to consider when discussing price slides. The lighter the delivery weights, the longer the cattle will be on hand before they reach slaughter weights. Delay in cash flow and an increase in maintenance cost also is a consideration when cattle must be held for longer periods.

Livestock Market Terms

Car load
Average of 25 yearling cattle per deck of a semi-truck or 125 sheep (50,000 pounds maximum loaded weight of animals).

Demand
Desire to possess a commodity coupled with the willingness and ability to pay. Terms describing demand are:

Very Good – Offerings or supplies are being rapidly absorbed.

Good – Buyers are confident that general market conditions are good and trading is more active than normal.

Moderate – Average buyers are interested in trading.

Light – Demand is below average.

Very Light – Few buyers are interested in trading.

FOB
Free on Board or without charge to the buyers for placing goods aboard a carrier at the time of shipment.

Market
A geographical location where buying and selling occurs and price levels are set.

Market activity
Buying and selling animals. Terms describing market activity are:

Active – Supplies are readily clearing.

Moderate – Supplies are clearing at a reasonable rate.

Slow – Supplies are not readily clearing.

Inactive – Sales are intermittent.

Pencil shrink

An agreed upon deduction from scale weight when arriving at pay rate, expressed as a percent.

Price trend

Direction in which prices are moving in relation to trading in the previous reporting periods. Terms describing price trends are:

Higher – Majority of sales are at prices measurably higher than the previous trading session.

Firm – Prices tend to be higher but not measurably so.

Steady – Prices are unchanged from the previous trading session.

Weak – Prices tend to be lower but not measurably so.

Lower – Prices for most sales are measurably lower than the previous trading session.

Supply or offering

Quantity of a particular item available for current trading. Terms describing supply are:

Heavy – Volume of supplies is above average for the market being reported.

Moderate – Volume of supplies is average for the market being reported.

Light – Volume of supplies is below average for the market being reported.

Quality grade

The grades of Prime, Choice, and Select are assigned by United States Department of Agriculture graders and based on factors related to palatability such as amount and distribution of finish, muscling, and maturity.

Yield grade

Indicates the proportionate amount of saleable retail cuts that can be obtained from a carcass (USDA 1, 2, 3, 4).

Hundredweight

100 pounds (cwt.).

Feedlot Operations

The feedlot or finishing phase of the livestock industry is not well understood by the average layperson. This phase uses feeder or stocker cattle with weights ranging from 500 pounds or more for cattle that have spent time on pasture. They will be fed to weights of 1,100 pounds or more, so they will reach USDA carcass grades Choice or High Select. Oklahoma State University classifies small feedlots as those that feed 35,000 head or less, and large feedlots feed more than 35,000. The lots rotate their capacities approximately 2.5 times per year. Feedlot buyers have become very attentive to traits associated with profit. Although feed prices are an important factor in profit or loss, other items such as rate of gain, health, and feed efficiency cannot be overlooked. An average steer gains 1.85 pounds per day in the feedlot. If the lot invests $.25 per day into yardage costs (with corn at $2.75 per bushel), the overhead cost amounts to 20 percent of the cost per pound of gain. If the rate of gain could be increased to 3 pounds per day, the overhead costs would approach 10 percent. Table 7 shows how feedlots rate the importance of various traits in the cattle they buy.

The producer who retains ownership through the feedlot phase knows these traits are of equal importance and will dictate a breeding program that emphasizes them. In the future, properly managed genetics and cattle packaging by biological types will become a more common marketing tool. Individual cattle identification based on feedlot performance may be traced by a passive transponder implanted in the ear, which will signal when the animal eats or drinks. Time spent at the feed bunk is a good indication of feed efficiency and rate of gain. This system, which is being adopted by commercial feedlots, eliminates others used in the past for research.

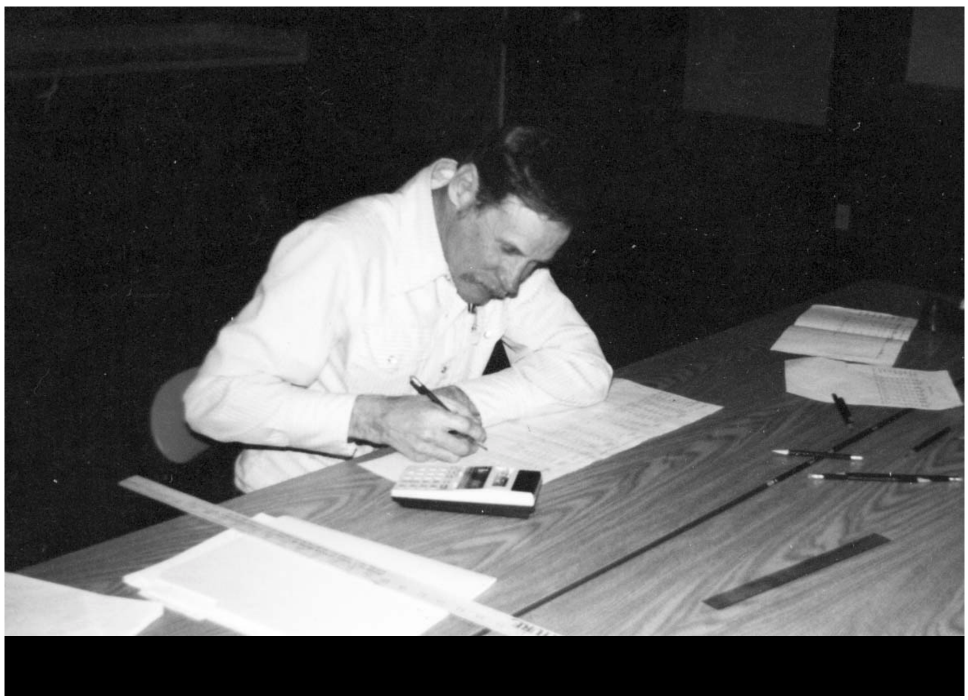
Table 7. Importance of feeder cattle traits to survey participant feed lots.

Trait	Score (1 to 10)
Feed efficiency*	9.4
Health	9.4
Misfits	9.1
Price	8.7
Biological type (breed)	8.4
Muscling	8.4
Daily gain	8.2
Frame size	8.2
Weight	6.8
Origin	6.5
Color	4.5

** Pound of feed required per pound of gain. Faster gaining cattle usually will have higher efficiency.*

Chapter 8

Cattle Economics



The following information and accompanying budgets have been adapted from those reported for the western states in 1996. The herd sizes are somewhat smaller than may be typical for a Wyoming ranch.

Assumptions (cow/calf operation on BLM range)

Cattle class	*Number*	*Productive life (years)*
Mature cows	275	5
Bulls	11	2
Calves weaned, 90%	247	—
Replacement heifers, retained annually	52	—
Horses	4	—

Cow/Calf Operation on BLM Range

Seventeen percent of mature cows are culled annually, and 2 percent of the herd is lost through death; therefore, 52 replacement heifers are retained. The functional equipment consists of the usual pickup trucks, tractors, and trailers.

Management Practices

Cows calve mid-February to mid-April, and they winter on private land or are fed hay from November 1 to April 1. The herd is maintained on BLM range the remainder of the year. Labor for one hired person is valued at $6.75 per hour and includes payroll taxes and employee benefits.

Operating and Return Costs

Tables 2 and 3 show examples of operating and return costs; the total represents all costs included in the analysis.

Ownership Costs

This category includes equipment depreciation, purchased bulls, interest on retained cattle, taxes, and insurance.

Table 1. Gross receipts.

Cattle class	Weight (net pounds)	Head count	Price (cents)	Total value (dollars)	Cow value (dollars)
Steer calves	440	124	.75	$40,920	$148.80
Heifer calves	390	72	.69	19,375	70.46
Cull bulls	1500	5	.40	3,000	10.90
Cull cows	1000	41	35	14,350	52.50
Cull heifers	800	6	.67	3,216	11.70
TOTAL				$80,861	$294.00

Table 2. Operating costs (BLM operation).				
Cost item	Number of units	Cost per unit	Total	Cost per cow
Hay	174 tons	$70.00	$12,146	$44.00
BLM	2,337 AUM's	$1.75	$4,089	$14.87
Private pasture	1,669 AUM's	$10.00	$16,690	$61.00
Salt	5,616 pounds	$0.06	$337	$ 1.23
Marketing	275 head	$5.90	$1,617	$ 5.90
Vehicles	1 - 4 X 4	---	$4,278	$15.60
Hired labor	1,711 hours	$6.75	$11,550	$42.00
Interest	10 percent	---	$25,949	$ 9.44
Total			$69,940.00	$254.00
Income above operating costs			$10,921.00	$ 39.70

Table 3. Costs and returns (BLM operation).		
Total ownership costs	$34,475	$125.40 per cow
Total costs	$104,415	$380.00 per cow
Total returns to management	-$23,554	- $85.70 per cow

Private Pasture and BLM and Forest Service Range

Calf weights averaged heavier per cow; feed costs were higher; other costs remained essentially the same as for the previous BLM enterprise. Not all cows in the example used federal range (see Table 4).

Summer Stockers on BLM Range

Stocker enterprise budgets are difficult to interpret and compare because of the differences in whether they are owned or taken on a monthly fee or rate-of-gain basis. Compounding the confusion are private pasture rates (owned and/or leased), licensed Federal Animal Unit Months (AUM), and surcharges on unowned cattle. Efforts are being made to unravel these effects and arrive at average costs such as those shown in Table 5.

Comparison of Operating Costs per AUM on Public Land Versus Private Ranch Rangeland

The costs shown for the public land ranch (see Tables 6 and 7) were updated from

USDA agricultural prices published in 1977. The costs of increased demands currently placed on permittees are not included but are higher than those in 1977. No costs for private grazing leases are shown, as this is a private ranch (no outside grass). Similarly, no capitalized costs of the federal permit(s) are included but run from $6 to $15 per AUM for the purchase price of the base property. Federal grazing permits are recognized by the IRS as production assets and are taxed in estate settlements. Cost for a Federal AUM varies annually, so an average cost has been used.

Costs and profits with stocker or grass cattle vary widely. Seasonal precipitation, vegetation type, weighing agreements, and cattle prices are influencing factors.

Table 4. Costs and returns for BLM and Forest Service.

Total receipts	$71,599	$358.00 per cow
Total operating costs	$72,109	$360.50 per cow
Income above costs	-$509	-$2.55 per cow
Ownership costs	$23,335	$116.70 per cow
Return to management	-$23,844	-$119.00 per cow

Table 5. 1000 Head stocker operation.

Operating costs (3 year average)	$75,258.00
Net income (3 year average)	$2,980.00
Net per head	$2.98 (3-year average)

Note: Average income per head for the three-year period ranged from a loss of $9.95 to a profit of $9.54. This profit/loss spread is minimal as it is common for the spread to be much wider.

Table 6. Public land ranch asset valuation (1992).			
	Per cow	Total	Percent
Livestock	$1,252.15	$500,858	27.69
Buildings and improvements	$398.59	$159,435	8.81
Equipment	$455.71	$182,286	10.08
Land	$2,268.07	$907,228	50.15
Federal permits	$93.43	$37,374	2.07
Other assets	$54.62	$21,849	1.21
TOTAL	$4,522.57	$1,809,029	100.00

Source: Publication B-993, University of Wyoming.

Table 7. Operating costs per AUM.		
Cost item	Public land	Private ranch
Lost animals	$1.82	$1.12
Veterinary	$0.53	$0.53
Moving livestock	$1.11	$1.16
Herding	$1.86	$0.77
Salt and feed	$2.09	$3.09
Travel	$1.53	$1.19
Water production	$0.27	$0.20
Horse	$0.50	$0 .31
Fences	$0.89	$0.92
Water management	$0.69	$0.55
Development depreciation	$0.37	$0.10
Other	$0.44	$0.47
Permit compliance	$0.27	---
Grazing fee	$1.75	---
TOTALS	$14.12	$10.41

Chapter 9

Beef Quality and Yield Grades

In the United States, the two types of beef carcass grading are quality and yield grades. Quality grades indicate taste and tenderness of meat. Yield grades estimate the percentage of boneless and closely trimmed retail cuts obtained from the carcass in the form of the round, loin, rib, and chuck cuts.

Quality Grades

USDA beef-quality grades for carcasses are Prime, Choice, Select, Standard, Commercial, Utility, Cutter, and Canner. These grades are determined based on the balancing of maturity and the degree of marbling.

Maturity is ranked in five groups:

Maturity group	Age
A	9 to 30 months
B	30 to 42 months
C	42 to 72 months
D	72 to 96 months
E	more than 96 months

Fat deposited within the muscle is called marbling, which is evaluated in the rib eye muscle between the 12th and 13th ribs. The 10 USDA degrees of marbling are abundant, moderately abundant, slightly abundant, moderate, modest, small, slight, traces, practically devoid, and devoid. Marbling is important because it has a direct influence on the juiciness and flavor of the meat when cooked.

Yield Grades

The five USDA yield grades range from 1 to 5. Yield grade 1 carcasses have the highest yield of retail cuts and yield grade 5 carcasses have the lowest. The percentage of retail cuts is the carcass cutability.

Yield grade	Percent of boneless, closely trimmed retail cuts from the round, loin, rib, and chuck
1	>52.3 percent
2	50 to 52.3 percent
3	47.7 to 50 percent
4	45.4 to 47.7 percent
5	<45.5 percent

The USDA yield grade is based on four factors:

1. **Adjusted fat thickness.** This is the amount of fat measured at the 12th rib. External fat is the most important yield grade factor. As the amount of fat increases, muscle decreases as a percent of carcass weight.

2. **Percentage of kidney, heart, and pelvic (KHP).** This is the amount of fat deposited around the kidney, heart, and pelvic cavity. The weight of the fat is based upon the percent of carcass weight. Most carcasses typically have 1 to 4 percent KHP.

3. **Rib Eye Area.** The rib eye area is measured in total square inches of muscle, an indicator of carcass muscling. As the ribeye muscle area increases, the retail cut yield increases. An average range is from 9 to 17 square inches.

4. **Hot Carcass Weight.** This is the weight of the carcass after it has been processed prior to being put in the cooler. As the carcass weight increases, the percentage of retail cuts may decrease if a higher amount of fat is present, reducing the yield grade.

Yield grades are calculated by using the following formula:

YG = 2.50 + (2.50 x adjusted fat thickness, inches)

+ (0.20 x kidney, heart and pelvic fat percent)

+ (0.0038 x hot carcass weight, pounds)

– (0.32 x rib eye area, square inches)

USDA grading drops the decimals, and yield grades are presented as whole numbers.

Chapter 10

Range Improvements

The purpose of range improvements is to facilitate available forage. However, adequate range developments do not mean that adequate range management automatically follows. The number of unused or underused AUMs that become available because of a range development is the criteria that dictates if it is economically feasible. Figure 1 illustrates how this might apply to water developments when the cost can be estimated and the number of acres needed to support a cow per month (an AUM) is known.

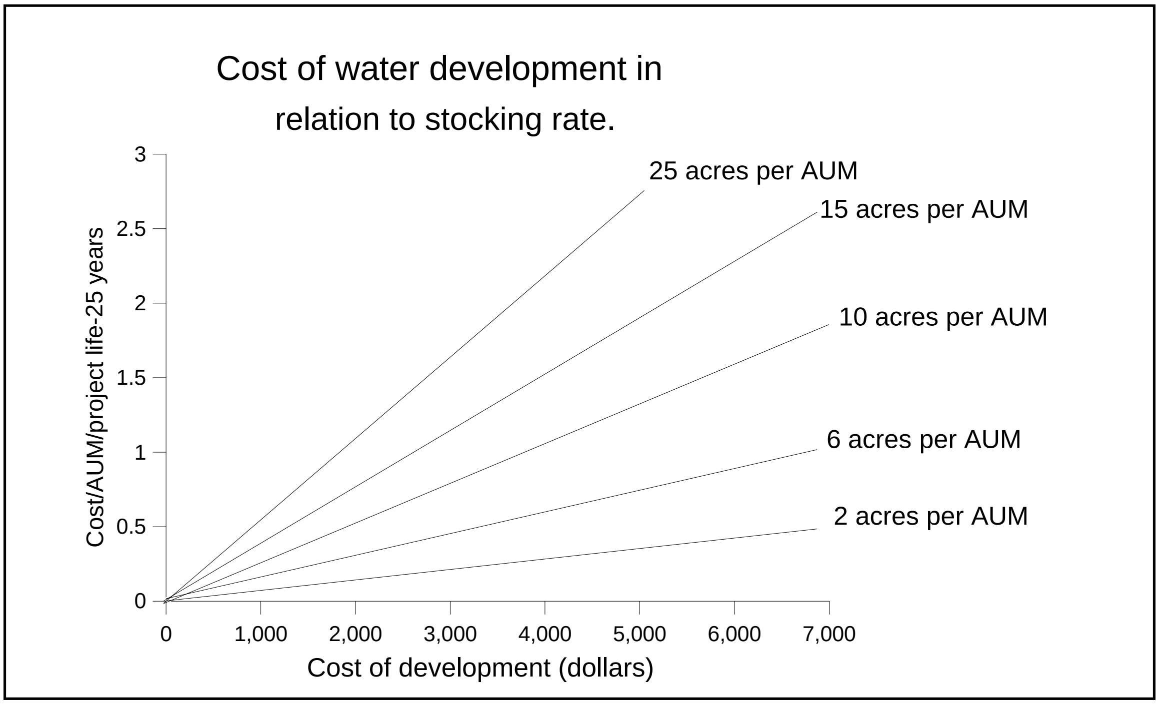


Figure 1.

Average water consumption rates by different cattle classes need to be known when determining if a water development is adequate to meet requirements. Guides for daily water intakes by different classes of animals are listed below.

Cattle class	Gallons per day
Cows and calves	15
Dry cows	10 to 12
Yearlings	8 to 9

When yearlings water on alternate days, consumption is reduced to an average of approximately 6.5 gallons daily. Cattle on lush forage require less. If wildlife also are watering at a tank or spring development, they will consume additional amounts as indicated below.

Species	Gallons per day
Elk	4 to 6
Deer	1 to 2
Antelope	0.5 to 1

This water development improved distribution and made lightly used forage available.

The daily consumption rates estimated for a particular number of animals then can be matched to a proposed spring development or well. The average daily (24 hour) production for various rates in gallons per minute is shown in the chart below.

Gallons per minute	Gallons per day
0.5	720
1	1,440
1.5	2,160
2	2,880
2.5	3,600

The distance cattle will ordinarily travel to water is another important factor when locating and establishing water developments.

Rough country	0.15 to .5 mile
Rolling terrain	0.50 to .75 mile
Smooth terrain	0.75 to 1.5 mile

Note: Desert cattle will travel considerably farther on smooth terrain but layover at the water source for 24 hours or more and not return for up to three days.

Estimates for maintenance costs on water developments range from 5 to 15 percent of the initial cost over the lifetime of the project.

Chapter 11
Brand Descriptions

Certain rules and methods are followed when naming or reading brands. Although all states do not use the exact same terms in their brand books, those generally accepted in Wyoming are given below.

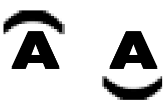
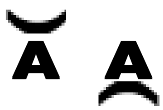
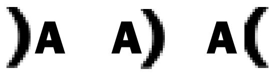
Brands are read from left to right, top to bottom, and outside to inside. The position of the brand figures is important when reading the brand. Those illustrated with the letter "F" read as follows:

 tumbling;  crazy;  lazy;  inverted;

 reversed;  F up and F down.

Several characters, modifications, and attachments that influence naming are used. These include circles, boxes, triangles, diamonds, rafters, and attachments like wings, legs, or spikes.

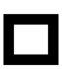
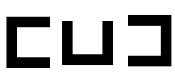
The difference between circles, O's, and zeroes is sometimes vague. Generally if the *character* is round, it is called a circle. If not perfectly round or part of an initial, it is called an O. If the character is part of a number, it is called by that number. The characters are not read separately. Examples include: **O–N** Circle Bar N; **DO** D.O.; and **30** Thirty.

Parts of circles, boxes, and diamonds often are used. Rules for quarter circles (or half circles) are:  called quarter circles;  reversed quarter circles, the second character is called "A over Quarter Circle;" and  standing quarter circles.

Naming is different if another figure touches the quarter or half circle such as 

 Hanging or Swinging A,  Rocking A, and  on Quarter Circle.

Boxes and diamonds are broken and used in parts much the same as circles, such as

 box,  half boxes,  open box,  diamond,

 half diamonds.

The triangle is not broken but often used in combination with another figure.

 Triangle and  Triangle E Combined.

Bars and slashes are commonly used with other figures in several combinations such as

, , , , , and others.

Rafters and open As are easily confused. The following two rules, however, usually separate them.

1. If the angle is more than 90° like , it is a rafter. If less than 90° like it is open A.

2. If the figure is above the other character, it is called a rafter, like . If below or to the side, like , it is an open A.

Any figure may have certain attachments made that help determine how it is named. Some of these are:

flying A, walking A, dragging A, and spikes.

Two or more figures are often combined or connected in the brand character. The way this is done determines what the brand is called. If two or more figures are used together as a single character, the designation is combined. If two or more figures are separate but hooked together, the designation is connected. Examples are or called T spear combined, or or called T spear connected. Another variation is spear intersecting T.

Most letter brands are capital letters because they are easier to read but it is common to see other forms. As an example the capital may be formed and called finished, or as and called running or script.

Other commonly used figures are: bench, arrow, spear, broken arrow, + crosses, • dots, and millirons. These are only a few of many in use.